April 2000

Vol. 24 No. 4

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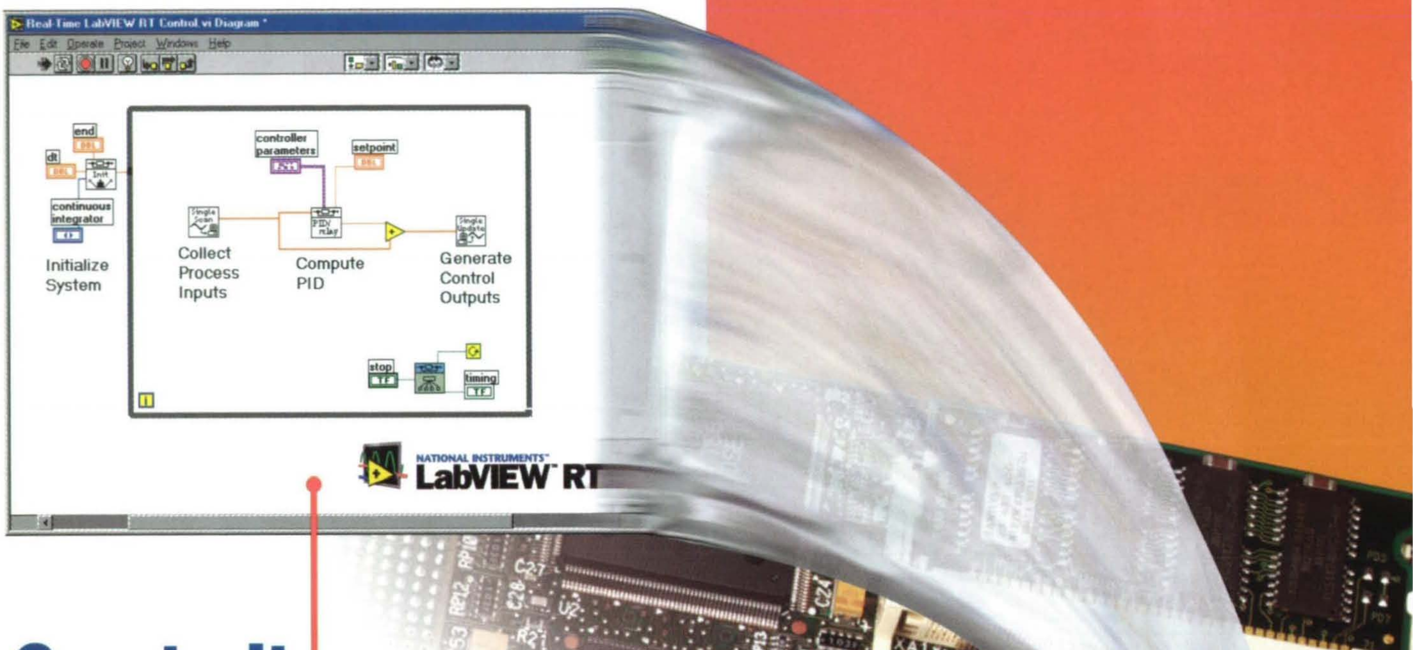

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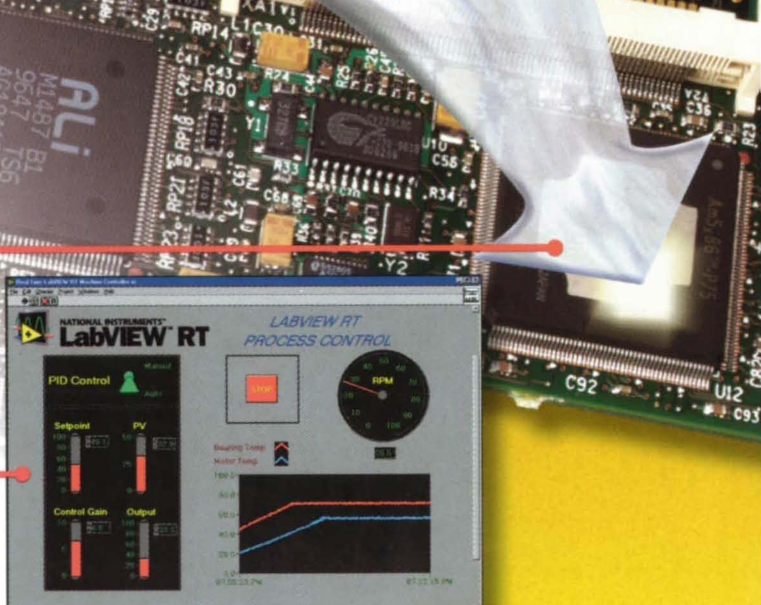

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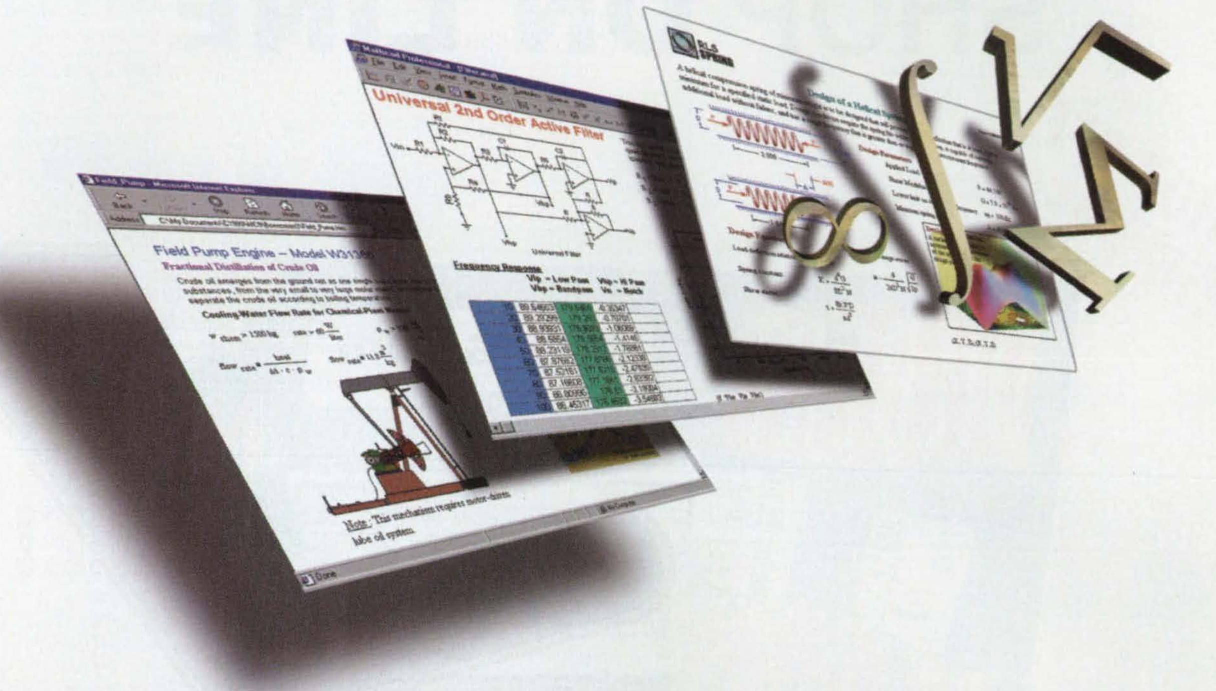

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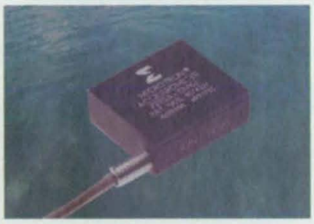

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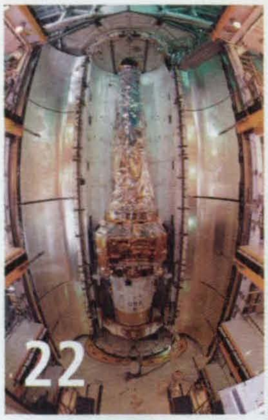

DEPARTMENTS

SPECIAL SUPPLEMENTS

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PRODUCT OF THE MONTH

Computer Dynamics' Century-C/M™ Series is a new family of flat-panel computers and monitors with 500-MHz computing power.

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ON THE COVER

Imaging, scanning, and electromechanical display innovations from NASA are featured in this month's Special Coverage on Imaging/Video/Display Technology, beginning on page 28. Also featured are video cards and scalers, imaging systems, and other new products, including the Century-C/M™ Series flat-panel computers and monitors from Computer Dynamics, Greenville, SC, our Product of the Month (page 20).

(Photo courtesy of Computer Dynamics)

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Selected technological strengths: Fluid Dynamics; Life Sciences; Earth and Atmospheric Sciences; Information, Communications, and Intelligent Systems; Human Factors.
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Dryden Flight Research Center
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Johnson Space Center
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Kennedy Space Center
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Langley Research Center
Selected technological strengths: Aerodynamics; Flight Systems; Materials; Structures; Sensors; Measurements; Information Sciences.
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John H. Glenn Research Center at Lewis Field
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Marshall Space Flight Center
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(408) 557-6700

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If you are interested in information, applications, and services relating to satellite and aerial data for Earth resources, contact: Dr. Stan Morain, **Earth Analysis Center,** (505) 277-3622.

Reader Forum

Reader Forum is devoted to the thoughts, concerns, questions, and comments of our readers. If you have a comment, a question regarding a specific technical problem, or an answer to a question that appeared in a recent issue, send your letter to the address below.

I'm looking for information on the Hybrid Electric Vehicle Analysis (HEVA) computer software from NASA's Lewis Research Center. The software was described in the January 1999 issue of NASA Tech Briefs ("Program Simulates Performance of a Hybrid Automobile," p. 46), and the on-line briefs information only goes back as far as March 1999. How can I get more information on this software?

John Bilash
jilash@mapcorp.com

(**Editor's Note:** *John, the software was written by D.K. Stalnaker and Larry Viterna at NASA's John H. Glenn Research Center (formerly Lewis Research Center) in Cleveland. You can contact Mr. Viterna at NASA Glenn's Commercial Technology Office at 216-433-3484 for more information.)*

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Mbonisi Tshabangu
mbo@angelfire.com

I'm looking for information on the effects of temperature and radiation on Kapton. Does anyone know of any web sites or reference books that may provide this information?

Soni
syl_apsp@hotmail.com

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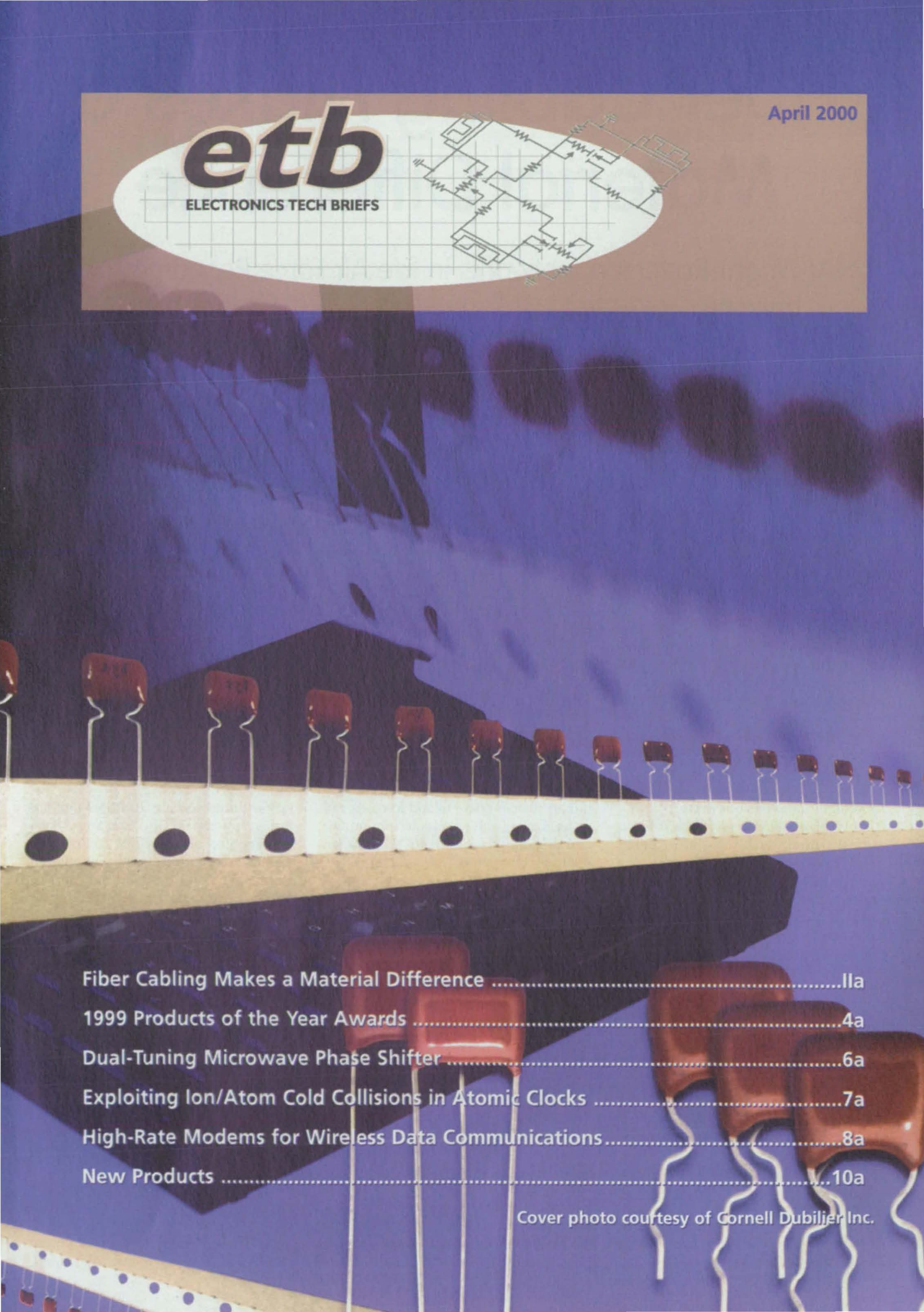
ELECTRONICS TECH BRIEFS

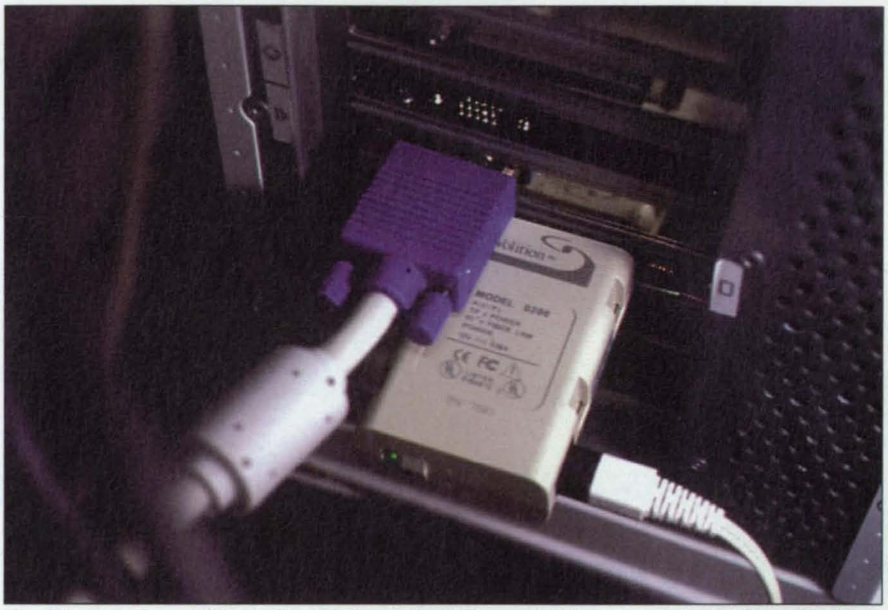


Cover photo courtesy of Cornell Dubilier Inc.

Fiber Cabling Makes a Material Difference

At Wright-Patterson, networks in five Air Force Research Lab buildings migrate to 3M's Volition optical fiber cabling.

The Materials and Manufacturing Directorate of the U.S. Air Force Research Laboratory is a major research and development arm of Air Force operations. From nuts and bolts to stealth paint, Air Force manufacturing programs and materials production are researched and directed by this directorate, headquartered at Wright-Patterson Air Force Base in Ohio. The directorate's data network consists of roughly 1300 nodes distributed among five buildings at the Wright-Patterson complex. Users conduct materials research with an array of graphics-intensive applications that generate very large files across the network. For example, computational chemistry, CAD/CAM, and finite-element analysis software programs routinely churn out files of more than 100 Megabytes in size. These are stored on Silicon Graphics Inc. servers and are frequently called up across the network for collaborative contributions from other members of the lab.



The 3M networking solution allowed the Air Force Research Laboratory to install fiber directly to the desktop.

More than 200 miles of 3M's Volition optical fiber cabling are being deployed among the five buildings as part of the directorate's network upgrade and desktop fiber migration. The lab's existing Fiber Distributed Data Interface (FDDI) backbone and shared 10-Mb/sec Ethernet local area networks (LANs), which used copper Thin-net (Category 3) desktop wiring, are being upgraded to a gigabit Ethernet backbone with switched 10/100-Mb/sec Ethernet to the desk.

"We decided to skip twisted-pair Category Five wire and go directly to fiber," says Bryon Foster, senior network manager for the directorate. The main reasons were fiber's unlimited bandwidth, the absence of radio frequency and/or electromagnetic interference, and the much more practical distance limitations using fiber.

"Fiber cabling just made more sense as we looked ahead," Foster says. "Then there's cost. By the time you factor in the money that you have to add to copper in order to deal with its distance limitations and shielding requirements, the Volition fiber costs the same."

Sold on the Desktop

Foster's group originally planned on a more limited fiber installation, just across the backbone, until 3M arrived with the Volition networking solution. Then it chose to go ahead and completely recable to the desktop.

Installation started in July with a backbone upgrade to one building, essentially a trial run. The other four building quickly followed, totalling nearly 13,000 feet of 24-strand Volition multimode fiber cable. The new Volition backbone supports existing FDDI devices, such as SGI servers, using Volition-brand media converters. The directorate is currently evaluating Gigabit Ethernet backbone switches from several vendors, and will connect those devices to the Volition system using 3M's Gigabit network interface cards (NICs) that feature a VF-45 jack.

Now under way are 19 floors that are divided among the five buildings. Each floor requires about 13,000 feet of four-strand desktop fiber, with installation proceeding floor by floor over several months as funding arrives. "There's no immediate timetable," Foster says. "We started this year with the fiber installation because it's the most fundamental change. As funding becomes available and the new equipment arrives, we'll start activating the desktop fiber and completing the installation on any floors that remain."

The existing shared 10-Mb/sec Ethernet LANs are being replaced by switched Ethernet. Most users will have a 10-Mb/sec link to the network, but some users and devices required 100-Mb/sec connections. Centralized servers, such as the SGI servers on the backbone, will use switched Gigabit links. The improved longer-distance run of fiber cabling compared to copper allows the network to be built without multiple hubs on every floor. This saves real estate and equip-

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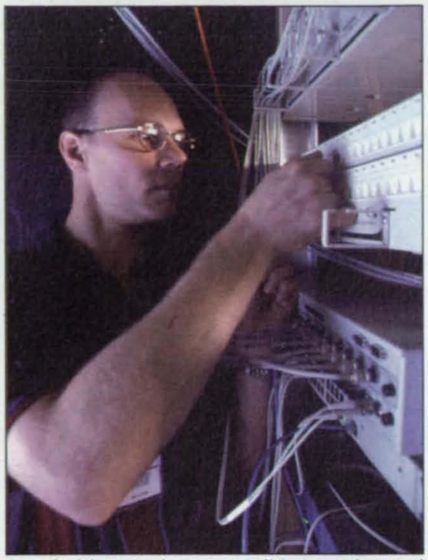


A technician works on a Volition patch panel inside the telecommunications closet.

The desktop media converter, center background, for the 3M Volition system.

ment costs, and allows more flexible deployment options.

Foster intends to compare two different topologies for feeding desktop traffic to the backbone. The first option is to configure each floor with a 10-Mb Ethernet switch, with every floor switch connected by a 100-Mb uplink to a Fast Ethernet switch in the building. The 100-Mb building switches then feed the Gigabit backbone.

The other option is to connect each floor directly to the Gigabit backbone, using a Fast Ethernet uplink. "We'll monitor the network to see what works best," Foster says. "Right now, if we lose one switch then we lose that floor, but if we lost a 100-Mb building switch, then we'd lose that whole building." With multiple uplinks and load balancing between switches, however, it should be possible to deploy a fault-tolerant switched hierarchy from 10-Mb to 100-Mb to Gigabit nodes. The Volition fiber cabling itself can easily accommodate any network design.

Field Experience

"The learning curve was very short, as quick as could be," says Sylvester S. "Bud" Lucas, manager of the Wright-Patterson Field Service Enhancement (FSET) 88th Communications Group that handled the installation. The FSET has installed thousands of feet of fiber with traditional ferruled connectors for other Air Force projects over the years, and so approached the ferrule-less Volition system with skepticism.

"We have people on the team with 20 or 30 years of field experience," Lucas says, "so the technician that 3M sent out to the Volition training was up against some serious expertise."

For example, setting up a system to test the installation using the FSET's existing test equipment was a major requirement. Whereas traditional fiber optics are tested one fiber at a time, the Volition system is a full-duplex technology that requires testing of two fibers at once. The FSET was concerned that its Microtest Inc. CertiFiber system could not reference two fibers simultaneously. The solution turned out to be straightforward and simple: 3M's field technician showed the team how to configure its CertiFiber system to connect test jumpers to pairs of fibers at a time.

In the end the Volition cabling and termination posed no difficulties at all. "The terminations are fast and easy, and the cabling itself is about half as bulky as other stuff we've used," Lucas said. "The fact that it takes up half the space is a major feature—making the installation that much easier to work with."

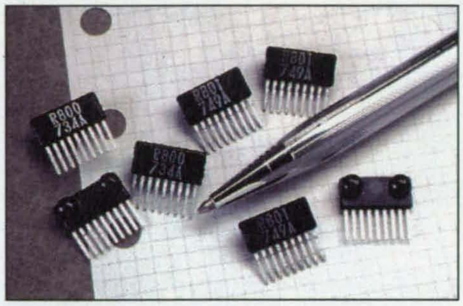
For more information contact 3M Telecom Systems Division, 3M Austin Center, Building A130-2N-01, 6801 River Place Blvd., Austin, TX 78726-9000; (800) 426-8688; fax: (800) 626-0329; www.3m.com/telecom.

Electronics Tech Briefs

1999

Readers' Choice Product of the Year

Readers' votes for *Electronics Tech Briefs'* 1999 Product of the Year have been tallied, and the winners are:



Gold Winner

and

Product of the Year:

Rohm Corp. (Antioch, TN) RPM800 Series IrDA Wireless Communication Devices for use in portable electronics equipment

Silver Winner

Fluent Inc. (Lebanon, NH) Icepak™ Computational Fluid Dynamics Software, for thermal analysis and electronics design

Bronze Winner

Sharp Microelectronics (Camas, WA) Single-Chip Surface-Mount White LED

Other finalists include: **National Semiconductor Corp.** (Santa Clara, CA) Analog-to-Digital Converter, **Microcal Software** (Northampton, MA) Origin® 6.0 Data Analysis and Technical Graphics Software, and **LPKF Laser and Electronics** (Beaverton, OR) ProtoMat® Printed Circuit Board Prototyping System.

Winners were chosen by reader vote on Electronics Tech Briefs' *web site from among the six Products of the Month nominated by the editors during 1999.*

Dual-Tuning Microwave Phase Shifter

This device can be tuned electrically, magnetically, or both.

etb COMPONENTS

John H. Glenn Research Center, Cleveland, Ohio

A microwave phase shifter that can be tuned by varying both electric and magnetic fields has been developed. This device combines all the advantages of prior electrically and magnetically tunable microwave devices, but in comparison with them, it is smaller and cheaper and it performs better. Devices like this one are suitable for use in monolithic microwave integrated circuits.

This microwave phase shifter is a thin-film ferroelectric/ferrite device. One can alter the propagation of electromagnetic waves in such a device by (1) varying an applied electric field and thereby varying the permittivity of the ferroelectric layer and/or (2) varying an applied magnetic field and thereby varying the permeability of the ferrite layer.

Figure 1 depicts the device as a layered structure and as the main component of a phase-shifting circuit. The substrate is a polycrystalline yttrium iron garnet (YIG) ferrite material. In the fabrication of the device, buffer layers of Si_3N_4 and MgO were deposited on the substrate, then the ferroelectric layer was formed by ion-beam-assisted deposition of $Ba_{0.6}Sr_{0.4}TiO_3$ on the MgO. Then a transmission line comprising a central strip and two lateral ground-plane strips was patterned on an electron-beam-evaporated gold film.

In tests of this device, significant phase shift was observed at frequencies up to 18 GHz when an electric bias or a magnetic field was applied. For example (see Figure 2), at a bias of 250 V, phase shifts of 20° and 34° were observed at 7 and 9 GHz, respectively. When an externally generated magnetic field of 800 gauss was applied in tests at 5 and 6 GHz, phase shifts of about 230°

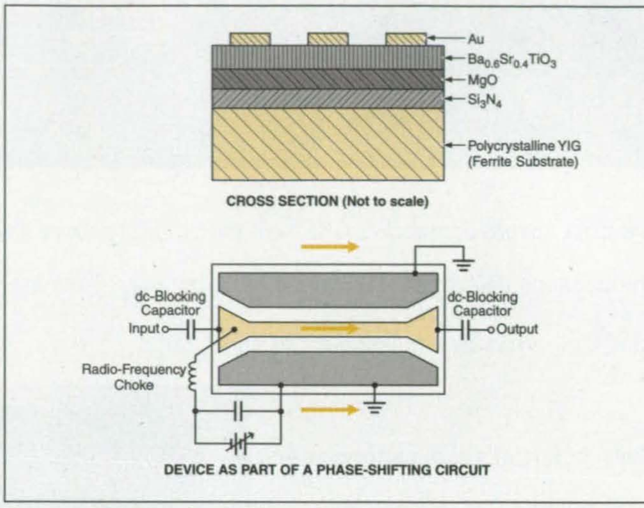


Figure 1. The **Ferroelectric Film and Ferrite Substrate** of this device have electrically variable permittivity and magnetically variable permeability, respectively. These characteristics can be exploited to control the phase shift between the input and output terminals.

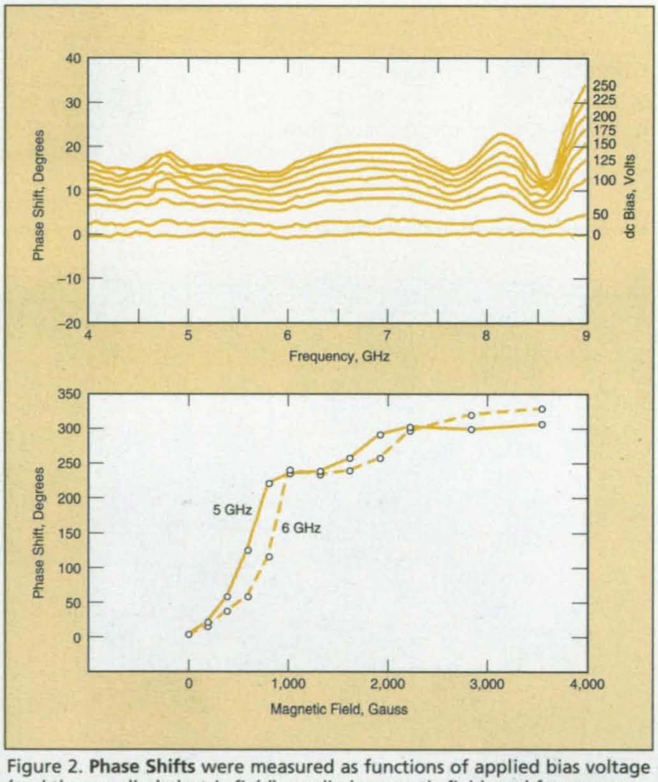


Figure 2. **Phase Shifts** were measured as functions of applied bias voltage (and thus applied electric field), applied magnetic field, and frequency.

were observed. As the magnetic field was increased beyond 800 gauss, the phase shift gradually saturated at about 300°.

This work was done by Hua Jiang of NZ Applied Technologies for **Glenn Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16762.

Exploiting Ion/Atom Cold Collisions in Atomic Clocks

Laser-cooled neutral atoms would be used to cool ions and perform other functions.

NASA's Jet Propulsion Laboratory, Pasadena, California

Recent advances in laser cooling and trapping of neutral atoms in magneto-optic traps (MOTs) would be exploited in ion-trap-based atomic clocks, according to a proposal. Beams of laser-cooled neutral atoms would be used to: (1) put the ions in the required quantum states (e.g., spin-polarize the ions) in preparation for quantum state transitions that define the clock frequencies, (2) cool the trapped ions to reduce clock instabilities from second-order Doppler shifts of clock frequencies, and (3) monitor the clock quantum state transitions. The cooling, state preparation, and monitoring would occur via ion/atom collisions.

The proposal is based on a complex of interdependent physical phenomena that include elastic and inelastic collisions among ions and neutral atoms, electric polarization of neutral atoms by nearby ions, spin-exchange and charge-exchange reactions among neutral atoms and ions, and radiative state transitions. For the sake of brevity, the proposal is described below by way of an example: how it would be applied to an atomic clock based on $^{199}Hg^+$ ions in a linear ion trap.

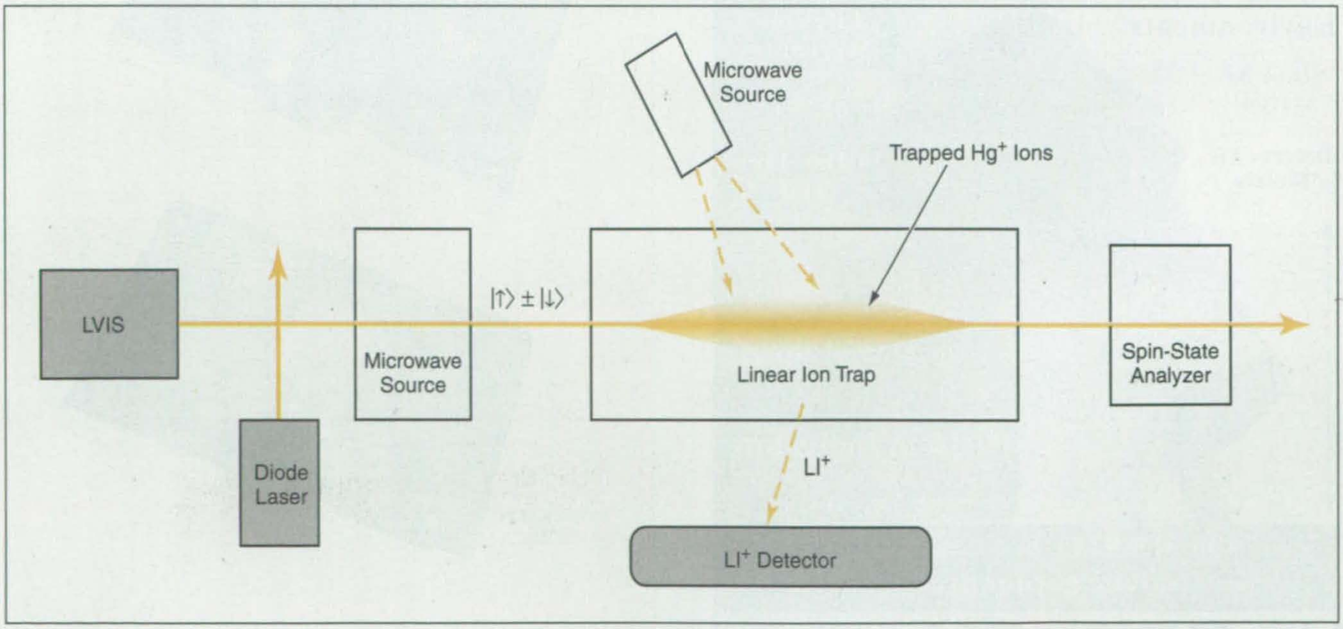
Atomic clocks of this type were described in several previous articles in *NASA Tech Briefs*. To recapitulate: a clock of this type includes a microwave local oscillator, the frequency of which is stabilized by comparison with the frequency (about 40.5 GHz) of a ground-state hyperfine transition of $^{199}Hg^+$ ions. The ions are held in a linear ion trap to obtain a long interrogation time and thus a high resonance quality factor. Heretofore, the cooling of ions and the comparison of frequencies has involved a combination of ultraviolet (wavelength = 194 nm) and microwave excitation and interrogation of the ions. The generation of the excitatory ultraviolet light is difficult and expensive because one must use multiple visible lasers that generate watts of power, together with delicate frequency-doubling crystals.

The proposal would eliminate the need for the ultraviolet light. The proposal is based partly on the observation that it would be easier and less expensive to use small diode lasers to generate visible light and use this light to cool neutral Li atoms in an MOT. The light from the laser diodes would be carried by optical fibers and split into three intersecting, retroreflected, circularly polarized beams that would effect the cooling in the MOT; this would all be accomplished by use of off-the-shelf components.

The figure schematically depicts an apparatus that would be used to test the proposal. The MOT would be the heart of a low-velocity intense source (LVIS) of a cold beam of neutral Li atoms. The beam would be directed into the linear ion trap of an atomic clock. In the trap, the $^{199}Hg^+$ ions would be cooled and state-prepared via collisions with the neutral Li atoms. Li^+ ions would be generated as byproducts of a spin-dependent charge-transfer interaction that would occur as a result of the microwave-induced clock transition in the $^{199}Hg^+$ ions. In the radio-frequency electric field that traps the $^{199}Hg^+$ ions, the motion of the Li^+ ions would be so great that the Li^+ ions would be immediately ejected from the trap. The ejected Li^+ ions could thus be used to indicate the clock transition; for this purpose, the ejected Li^+ ions could be detected by channeltron electron multipliers surrounding the trap. Assuming detection of all ejected Li^+ ions, the short-term clock stability has been estimated to be $\approx 10^{-14}\tau^{-1/2}$, where τ is the averaging time in seconds.

This work was done by John Prestage of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP) free on-line at* ***www.nasatech.com*** *under the Physical Sciences category.*

NPO-20365



Lithium Atoms Would Be Cooled by laser beams in the LVIS. The resulting beam of lithium atoms would be spin-polarized by optical pumping on its way to the linear ion trap, where it would cool and spin-polarize the $^{199}Hg^+$ ions. Li^+ ions generated as a byproduct of the microwave-induced transition in the $^{199}Hg^+$ ions would be ejected and detected. Depolarization of the beam of lithium atoms could be detected in a spin-state analyzer by optical fluorescence following excitation by a diode laser.

High-Rate Modems for Wireless Data Communications

Innovative design affords high performance at relatively low cost.

etb COMMUNICATIONS

John H. Glenn Research Center, Cleveland, Ohio

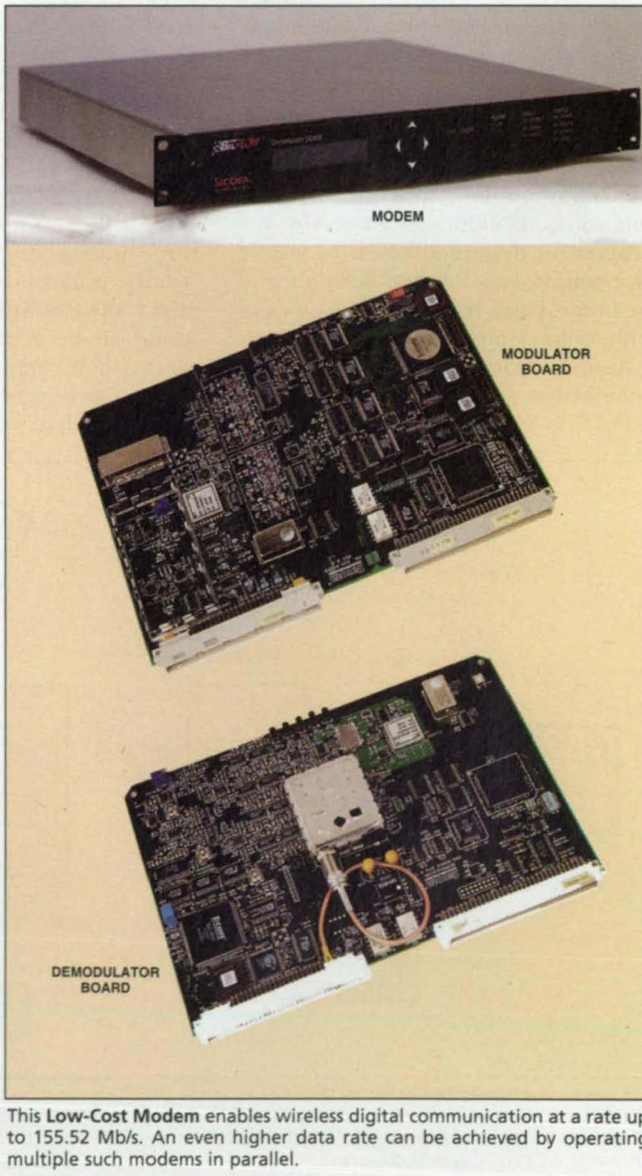
A NASA Small Business Innovation Research (SBIR) project has led to the development of high-rate (155.52-Mb/s) modems for use in high-quality wireless data communications. The research was directed toward conceiving innovative signal-processing techniques to reduce costs below those of conventional modems, implementing these techniques in a low-power complementary metal oxide semiconductor (CMOS) application-specific integrated-circuit (ASIC) modulator and a corresponding demodulator, and developing the necessary circuit boards (see figure) and control software. An additional goal of the research was to determine the maximum rate at which data can be transmitted through a standard 72-MHz-wide satellite-transponder channel.

The research revealed that the primary barriers to reducing the costs of high-rate modems lay in (1) expensive high-power amplifiers (HPAs) needed to support high rates and higher-order, more bandwidth-efficient modulations; (2) expensive frequency converters that satisfy stringent phase-noise requirements; and (3) expensive high-resolution, high-rate analog-to-digital converters (ADCs). The research then focused on the development of modulation/demodulation and coding/decoding techniques to overcome each of these cost barriers.

One of the innovative features of the modem design is the use of pragmatic trellis coded modulation (PTCM) to reduce (1) the required power and other required performance parameters and thus (2) the cost of the power amplifier. The modem is capable of a fully rotationally invariant octonary-phase-shift-keying (8PSK) PTCM; this means that it is possible to flywheel through a cycle slip with no loss of data — a crucial benefit for Earth/satellite wireless data communications.

The design incorporates analog-matched-filtering and single-sample-per-baud concepts that, in combination, greatly reduce cost and complexity, relative to modems developed previously for the same purpose. The design supports low-complexity modulators by providing for square-root-Nyquist pulse shaping with programmable predistortion and programmable values of α. This programmability enables a communication-link designer to trade α and HPA backoff for a fixed baud rate to achieve the maximum possible data rate through a transponder channel.

Another innovative feature of this modem stands in contrast to the conventional means of converting a stream of 4 complex samples per baud into quadrature analog baseband waveforms. In the conventional approach, the streams are



This **Low-Cost Modem** enables wireless digital communication at a rate up to 155.52 Mb/s. An even higher data rate can be achieved by operating multiple such modems in parallel.

multiplexed and passed through a very fast digital-to-analog converter (DAC); not only is a fast DAC expensive, but the board and assembly costs are high because of the need to use emitter-coupled-logic components (latches, clock drivers, and so forth). In this modem, the conventional high-speed DAC is replaced with four baud-rate DACs, thereby effecting a significant reduction in cost. Moreover, unique data encoding and pulse shaping reduce (in comparison with that of a typical previously developed modulator) the maximum stop-band energy level by nearly 12 dB, further enhancing modulation quality.

In a comparative test against a state-of-the-art high-rate European modem, this modem demonstrated superior performance in the transfer of data through a satellite transponder, the ability to function properly with frequency translators that cost only 1/40 as much as do the frequency translators in the European modem, and an overall cost of one-fourth of that of the European modem. In other tests,

- Transfer of data at the design rate of 155.52 Mb/s was demonstrated in a laboratory environment; and
- Transfer of data at a rate of 75 Mb/s was demonstrated through a 36-MHz-wide transponder channel, using a rate-5/6 PTCM and 8PSK.

The modem is also expected to support a 16-state quadrature amplitude modulation (16QAM), 155.52-Mb/s link, using a Reed-Solomon (187, 204) outer code and a rate-3/4 pragmatic trellis code. The link occupies a nominal frequency band 73.5 MHz wide, and it should be possible to accommodate the link in a standard 72-MHz-wide transponder channel; however, at the time of reporting the information for this article, a field test of the modem with such a link had not yet been performed.

This work was done by Ron McCallister, Bruce Cochran, and Jim Crawford of SiCOM, Inc. for **Glenn Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16668.

NEW PRODUCTS

PRODUCT OF THE MONTH

Point-to-Point Communications Link

Inova Semiconductors, Hyannis, MA, releases GigaSTAR, a universal high-speed point-to-point communications link. The name, derived from gigabit/s serial transmitter and receiver, is based on what the company calls a protocol-free and operating-system-independent data transmission architecture. Inova says the chipset provides the world's fastest transfer of serial data: up to 2.64 Gbits/s, over distances of up to 30 m, over standard twisted pair cable. For greater distances fiber optic cables can be used up to 200 m. Inova says that GigaSTAR uses just 10 percent of its bandwidth for link control and synchronization, and has a low 40-ns latency.

For More Information Circle No. 751

Handheld Oscilloscope/ Meter

Cole-Parmer Instrument, Vernon Hills, IL, says its new Fluke® Scope/Meter™ oscilloscope is three meters—oscilloscope, multimeter, and recorder—combined in one unit. The company says the compactness and light weight of the unit enable the user to carry it anywhere. Features include full video triggering with built-in line, frame selector, extensive triggering capabilities, TrendPlot™ logging, 30-k memory, glitch capture, RS-232 interface, and waveform math.

For More Information Circle No. 752

Signal Multiplexer Board

The SMB signal multiplexing board from H3 Technologies, Lowell, MI, is a general-purpose board designed for HVAC, process control, and remote data acquisition and monitoring. The SMB supports ±12-V signal inputs and buffered output. Each channel can have a gain of 1, 10, or 50, and there is a 3-digit 7-segment display for indicating selected channel and board status. The SMB supports standard ASCII character sequences for direct computer or embedded system control, even from a standard terminal program on a laptop.

For More Information Circle No. 753

High-Voltage Power Amplifiers

Apex Microtechnology, Tucson, AZ, offers the PA94 and PA95 high-voltage power amplifiers that operate on supplies of up to 900 V. Both are housed in a Power SIP design to reduce board-space requirements and feature a staggered pin configuration. In addition to a ±50-V to ±450-V supply, both models provide 100 mA of continuous output current and up to 200 mA pulse. The PA94 offers speed with a 500-V/µs slew rate, but external compensation allows flexibility in choosing bandwidth and slew rate. The PA95 idles quietly by offering a maximum standby current of 1.6 mA.

For More Information Circle No. 754

PCI Bus A/D and Scope Card

Gage Applied Sciences, S. Burlington, VT, says that its CompuScope 82G is the world's fastest PCI bus A/D and scope card, with sampling rates of 2 billion samples per second (2GS/s), up to 16 Mbytes of on-board acquisition memory, and wide analog bandwidth. Features include dual-channel simultaneous sampling of 1 GS/s, 500 MHz of bandwidth, and multicard systems allowing up to 16 simultaneous channels at 1 GS/s and 8 channels at 2 GS/s. Signal-to-noise ratio is 40 dB, and data transfer rate from on-board memory to PC memory is 100 MB/s.

For More Information Circle No. 755

Toroidal Inductors/ Transformers

Vishay Intertechnology, Malvern, PA, announces three new series of inductors/transformers in surface-mount toroidal packages. The new Dale LPT-3535 series offers designers a choice of Kool-Mu®, powdered iron, or MPP cores. With diameters of 8.93 mm (0.35 in.) and a height profile of 6.35 mm (0.235 in.), the devices come in 14 different inductance values from 1 µH to 330 µH. DC resistance is as low as 4 mΩ for a 1-µH component with a powdered iron core, with maximum current values as high as 6.45 A. Inductance tolerance is specified at ±15 for all devices.

For More Information Circle No. 756

Off-the-Shelf Crystal Oscillator

Fox Electronics, Fort Myers, FL, offers what it calls the first standard off-the-shelf crystal oscillator designed specifically for use with the Intersil Corp. PRISM® I, II, and III chipsets. Designated the F4106-440, the new CMOS oscillator comes in the industry-standard 5-×-7-mm ceramic SMD package. Fox says the device offers a very stable ±25 ppm. The oscillator features 3.3-V operation, a profile of 1.5 mm, a frequency of 44.000 MHz, and standard operating temperature range from -10 to +70 °C. Available on special order is a 22.000 MHz version for the PRISM I.

For More Information Circle No. 757

Quick-Disconnect Connectors

Tru-Connector Corp., Peabody, MA, says that its QDM series positive-locking quick-disconnect connects are equivalent to BNC/TNC interface dimensions. Constructed with brass bodies with a Tru-Lustre or silver finish, silver- or gold-finish contacts, and Teflon® insulators, the connectors are rated for 1000 V RMS, operate from DC to 11 GHz, and have 50-ohm impedance. They fit 0.100-in.- through 0.425-in.-diameter cables, and cannot be cross-threaded or vibrated loose.

For More Information Circle No. 758

Power Moisture Resistors

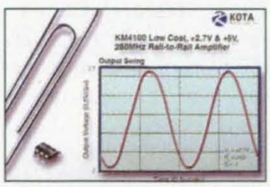
State of the Art Inc., State College, PA, has introduced power moisture chip resistors that it says are designed for engine controls, navigation systems, and other applications where circuits are exposed to excessive moisture or humidity. They are available in standard termination styles. Metallization options include solderable, epoxy-bondable, and wire-bondable. The company says the devices are constructed with an alumina body and a proprietary film resistor element that enhances performance and reliability while minimizing susceptibility to moisture and humidity.

For More Information Circle No. 759

Microwave Capacitors

American Technical Ceramics, Huntington Station, NY, says that its new 600 series of capacitors offers the lowest ESR in their class, typically 80 mΩ at 1 GHz. Designed for RF and microwave applications, the NRO capacitor suits requirements in which low loss and high performance are paramount, according to the company. With up to 100 pF in an 0603 case size, the 600 series has a rated voltage of 250 V. They are available laser-marked and in tape and reel.

For More Information Circle No. 760



Rail-to-Rail Amplifiers

KOTA Microcircuits, Loveland, CO, announces a family of amplifiers that includes the KM4100 (single), KM4101 (single with disable), and KM4200 (dual) single supply voltage feedback amplifiers. The family's supply voltage range is 2.5-5.5 V, and is fully specified at +2.7 V and +5 V. It is offered in small packages: SOT23-5 (KM4100), SOT23-6 (KM4101), and an SOIC (all three models). Bandwidth of the KM4100 is 260 MHz and slew rate 150 V/µs. KOTA says the series' combination of characteristics makes it well suited for battery-powered communications and computing systems.

For More Information Circle No. 761

Vol. 24, No. 4 April 2000 This form expires: September 30, 2000

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1b. If yes, do you plan to increase your purchase of CAD software in the next 12 months? ❑ Yes ❑ No

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3. Please list the names of CAD packages you (or your department) currently use.

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NASA Patents

Over the past three decades, NASA has granted more than 1000 patent licenses in virtually every area of technology. The agency has a portfolio of 3000 patents and pending applications available now for license by businesses and individuals, including these recently patented inventions:

Method of Manufacturing a Micromechanical Oscillating Mass Balance

(U.S. Patent No. 5,946,795)

Inventor: David A. Altemir, Johnson Space Center

Previously available microbalances suffer from one or more disadvantages, including high cost, poor sensitivity, susceptibiliy to thermal errors, and lack of durability. The present micromechanical oscillating mass balance and its method of production are particularly adapted to be used for measuring minute quantities of material deposited at a selected location, such as on a workpiece in an evacuated chamber during vapor deposition. This balance consists of a vibratory composite beam that includes a dielectric layer sandwiched between two conductive layers. The beam is positioned in a magnetic field. An alternating current is passed through one of the conductive layers, and interacts with the magnetic field, creating a force that deflects and vibrates the beam. As material is deposited on the beam, the mass of the beam increases and its resonant frequency shifts. An output current signal is induced in the second conductive layer as the beam vibrates in the magnetic field. The resonant frequency shift results in a shift in the frequency of the output signal, which is then analyzed to determine the mass of the deposited material.

Waterproof Silicone Coatings of Thermal Insulation and Vaporization Method

(U.S. Patent No. 5,939,141)

Inventor: Domenick E. Cagliostro, Ames Research Center

The successful operation of the space shuttle requires the development of lightweight and thermally efficient exterior thermal protection systems that can withstand a wide variety of environments. The present invention protects porous ceramic insulation from moisture by coating it with a flexible silicone film of Si, O, and C atoms that seals the insulation's surface. This coating waterproofs the insulation and prevents moisture from entering into its interior porous structure. The silicone coatings cure quickly at ambient or room temperatures, are relatively nontoxic, and are easily derived from commercially available organoprecursors of silicone. The silicone coatings are also easily reapplied. The term "silicone" means polymeric silicone which is a polymer comprising silicon, oxygen, carbon, and hydrogen having Si-O bonds, Si-C bonds, and C-Si-O bonds.

Solid State Carbon Monoxide Sensor

(U.S. Patent No. 5,948,965)

Inventors: Billy T. Upchurch, George M. Wood, David R. Schryer, Bradley D. Leighty, Donald M. Oglesby, Erik J. Kielin, Kenneth G. Brown, and Christine M. D'Ambrosia, Langley Research Center

Since carbon monoxide is such a toxic gas, the ability to detect its presence in homes, automobiles, and other such spaces is very important. Sensors currently on the market, however, exhibit extremely long response times and lack sensitivity to low concentrations of carbon monoxide. In addition, all of the low-priced sensors exhibit inordinately long recovery times after exposure to carbon monoxide. The inventors have developed a simple, low-cost carbon monoxide sensor that rapidly detects its presence at ambient temperatures. It comprises a catalytic material that achieves oxidation of carbon monoxide to carbon dioxide at relatively low temperatures. The material is from a class of catalytic materials comprising one or more noble metals in combination with a suitable reducible oxide. Since this chemical reaction is exothermic, heat generated upon the oxidation of carbon monoxide at the catalyst surface can be detected by a sensing element in contact with the catalytic material. An increase in temperature, and thus conductance, of the sensing element in relation to a reference element then serves as an indicator of the presence of carbon monoxide.

For more information on the inventions described here, contact the appropriate NASA Field Center's Commercial Technology Office. See page 14 for a list of office contacts.

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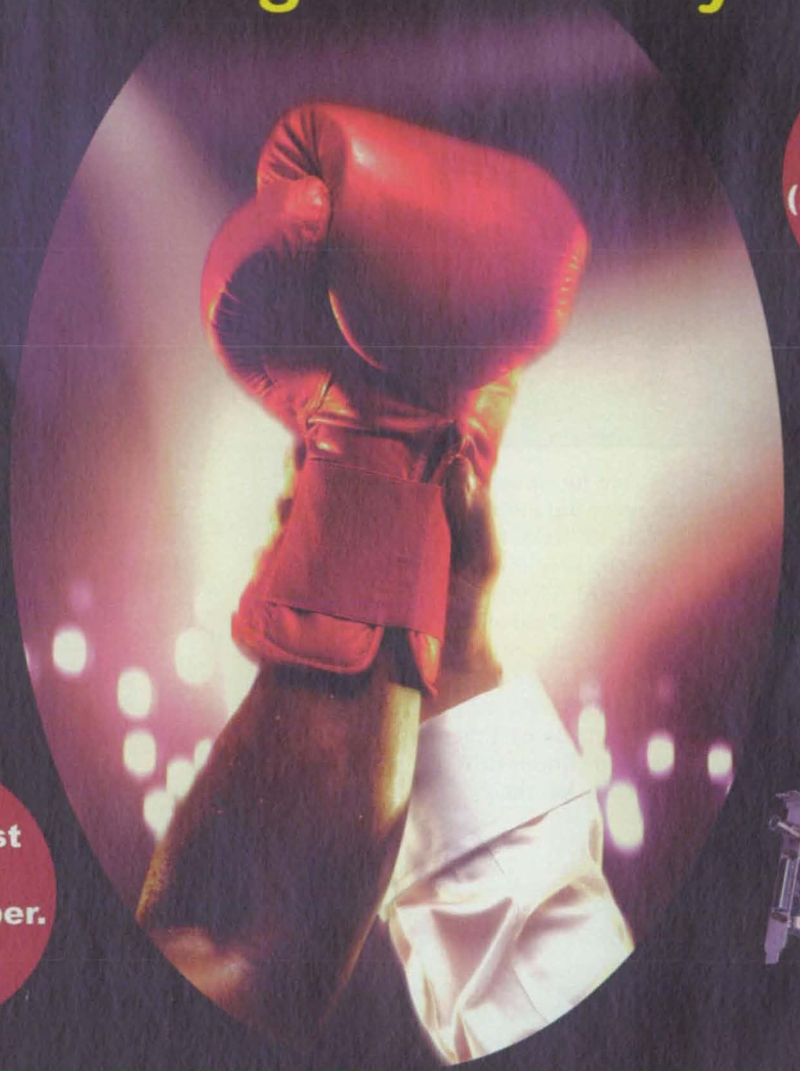

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UpFront

PRODUCT OF THE MONTH

Computer Dynamics, Greenville, SC, has introduced the Century-C/M™ Series of enclosed flat-panel computers and monitors available in four display sizes: 10.4" VGA, 12.1" SVGA, 15" XGA, and 18.1" SXGA. The units include an analog resistive touchscreen for operator input, and are available with or without a membrane keypad. The front display unit can be detached from the rear electronics unit. The flat-panel computers feature Celeron CPUs to 500 MHz, and the C&T 69030 video controller, which handles display resolutions to 1280 x 1024 with 24-bit color. The systems' standard PC functionality includes two RS-232 ports, two RS-232/422 ports, parallel port, mouse and keyboard/speaker connectors, 10/100BaseT Ethernet, 6.4-Gb hard drive, 128M DRAM, and a 1.44M front-accessible floppy drive.

For More Information Circle No. 765

Human Factors of Flying

NASA and the Federal Aviation Administration (FAA) are studying ways to reduce the concerns of the flying public by reducing airline delays, improving efficiency, and making flying safer. Researchers from both agencies are studying human-factors issues involving air traffic controllers, flight crews, and dispatchers that could occur as the FAA's Free Flight Program evolves in the next 10 to 20 years.

Free Flight is an FAA and aviation industry concept designed to increase operational flexibility and reduce restrictions in the National Airspace System. In the current environment, air traffic controllers separate aircraft. With the Free Flight system, pilots will be allowed more authority to choose and modify their own routes, in cooperation with the controllers. This should result in more efficient routing and reduced delays.

"The idea is to let the flight crews have more flexibility in resolving their own traffic conflicts and managing their own airspace," said Sandy Lozito, research psychologist and NASA project leader at Ames Research Center in California.

Participants in the air-ground experiment include qualified Boeing 747 pilots and air traffic controllers from the FAA's Memphis Air Route Traffic Control Center, in addition to NASA researchers and simulation and human-factors engineers. "We have five sets of participants, comprised of four controllers and two pilots," according to Mark Rogers, FAA chief scientist for human factors. "We are evaluating their workload and their situational awareness during several traffic-conflict scenarios they may face under Free Flight conditions."

For more information, contact Michael Mewhinney of Ames Research Center at 650-604-3937, or visit www.arc.nasa.gov.

NASA TECH BRIEFS

1999 Product of the Year

Your Winners Are ...

Your votes for the *NASA Tech Briefs* 1999 Readers' Choice Product of the Year Awards have been tabulated, and the winners are:

Gold Winner

and Product of the Year

CoBrain knowledge processing software from **Invention Machine Corp.** (Boston, MA)

Silver Winner

3Dmodelserver.com web-based 3D model repair application from **Spatial** (Boulder, CO)

Bronze Winner

CrystalEyes Wired stereoscopic eyewear system from **StereoGraphics** (San Rafael, CA)

The awards were presented at a special reception held during the National Design Engineering Show in Chicago. In next month's issue, we'll feature highlights of the Awards Reception. We'll also announce which readers are the winners of the random drawing for valuable prizes. If you voted in the Product of the Year contest, you're eligible to win!

Chandra Telescope Assembly and Testing Meet Stringent Requirements

Mirror and optics
Eastman Kodak
Rochester, NY
716-253-5790
www.kodak.com

Last July, the Space Shuttle Columbia carried Chandra, an advanced x-ray telescope, into space. Built by NASA contractor TRW, Chandra has begun to capture x-ray images of supernovae, black holes, and galaxy clusters. Kodak designed, assembled, aligned, and tested the Optical Bench Assembly (OBA), the backbone of Chandra, and the High Resolution Mirror Assembly (HRMA), the heart of the telescope.

The OBA supports the two-ton HRMA at the fore end, and the half-ton integrated science instrument module at its aft end, which contains the high-resolution x-ray camera and CCD imaging spectrometer. Constructed with honeycomb core panels, the OBA is the largest composite metering structure ever built for space use.


Photo courtesy of NASA

The HRMA contains eight mirrors — the largest of their kind and the smoothest ever created — which add up to almost two tons of glass optics. It measures 6 feet in diameter by 10 feet long. The HRMA was assembled and aligned to meet a stringent x-ray imaging requirement: it must focus x-ray energy from a distant celestial source onto a point that measures less than one-thousandth of an inch. This is equivalent to reading newsprint text from half a mile away.

In order to meet this requirement, Kodak addressed problems such as how to measure and control the mirror alignment, how to support the mirrors (at 450 pounds each) strain-free in a simulated zero-gravity environment, how to continuously maintain air temperature at 69.8° F, and how to achieve Class 100 cleanroom levels from assembly through placement in orbit.

According to Carl Marchetto, president of Commercial & Government Systems, the division responsible for the development of Chandra's HRMA and OBA, "the mirrors are assembled such that the resulting Chandra images will show 50 times more detail than any previous x-ray telescope. The results attained through the study of these images will change science textbooks for years to come," he added.

For More Information Circle No. 740

Space Station Couplings Protected by Commercial Coating

NEDOX® surface enhancement coating
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Linden, NJ
908-862-6200
www.magnaplate.com

In the harsh vacuum and low temperatures of space, the valves on quick-disconnect couplings (QDCs) on the International Space Station (ISS) must operate with total reliability. The couplings must be smooth, hard, and durable to alleviate the possibility of damage to the sealing surface during transportation or when opening and closing valves at temperatures as low as -107°C.

During long periods of exposure to the harsh conditions of space, any damage to the couplings' valves — even minute surface scratches — can result in system fluid leakage. Such gradual leakage would contaminate the ISS external facilities and/or its internal habitat. Extreme system cleanliness is vital, and contamination represents a constant danger.

Design engineers at the Parker Stratoflex Unit of Parker Hannifin Corp. achieved the hardness, durability, and smoothness required for the QDCs by treating them with NEDOX, a proprietary surface enhancement coating technology from General Magnaplate. NEDOX provided a thin film coating that permanently dry-lubricated the surface to a coefficient of friction as low as 0.06, while providing hardness of up to Rc68. The coatings create non-stick surfaces that are corrosion-resistant and prevent static build-up.

Stratoflex's valve components for the ISS couplings were manufactured from high-strength Inconel or stainless steel. The components were polished, cleaned, packed, and sent to General Magnaplate's Ventura, CA facility, where NEDOX was applied.

For More Information Circle No. 741

Adrian Stoica, Senior Researcher in Advanced Computing Technologies, Jet Propulsion Laboratory

Adrian Stoica is leading the research in Evolvable Hardware at NASA's Jet Propulsion Laboratory (JPL), Pasadena, CA. His current NASA/JPL projects also include Sensor Fusion Hardware, Rover Intelligence, and Robot Fostering.

NASA Tech Briefs: What is "evolvable hardware"?

Dr. Stoica: In the narrow sense, evolvable hardware (EHW) refers to reconfiguration of field progammable devices under the control of evolutionary/genetic algorithms. I prefer the more general meaning, in which I think of various forms of hardware — not only electronic hardware, but also mechanical, bio-electronic hybrids, MEMS, everything that has a reconfiguration/morphing capability — that can change itself and improve performance during its lifetime. In this sense, learning and adaptation techniques are included.

NTB: How is NASA using EHW?

Stoica: We are considering using EHW to increase the flexibility/versatility and survivability of spacecraft. The focus is on using EHW to automatically synthesize new circuits that can perform functions for which the need arises during the mission, or reconfigure to self-heal and recover functionality when damaged by radiation, extreme temperature conditions, aging, etc. The longer the mission and the harsher the environment, the more benefit EHW ideas can bring. Long-life survivable spacecraft (100+ years) would bring us closer to interstellar missions. Other areas of application include the evolution of artificial bacteria for harvesting local resources on another planet.

NTB: How does EHW "know" how or when to reconfigure/heal itself without human intervention?

Stoica: To give a simple summary, the response/behavior of a circuit is monitored through some measures even during its normal functioning and compared with a desired target response. Once part of the electronics is damaged, its behavior is altered — which translates into an increased distance from the desired behavioral response. Then, the genetic algorithm pops in and tries to find other configurations that would decrease the distance to the desired behavior. Configurations that include damaged areas have less fitness and are eliminated by evolution. In certain cases, a resource previously pulled out of one design may be brought back into another design, which exploits another aspect of its functionality.

NTB: What are some potential commercial applications for EHW?

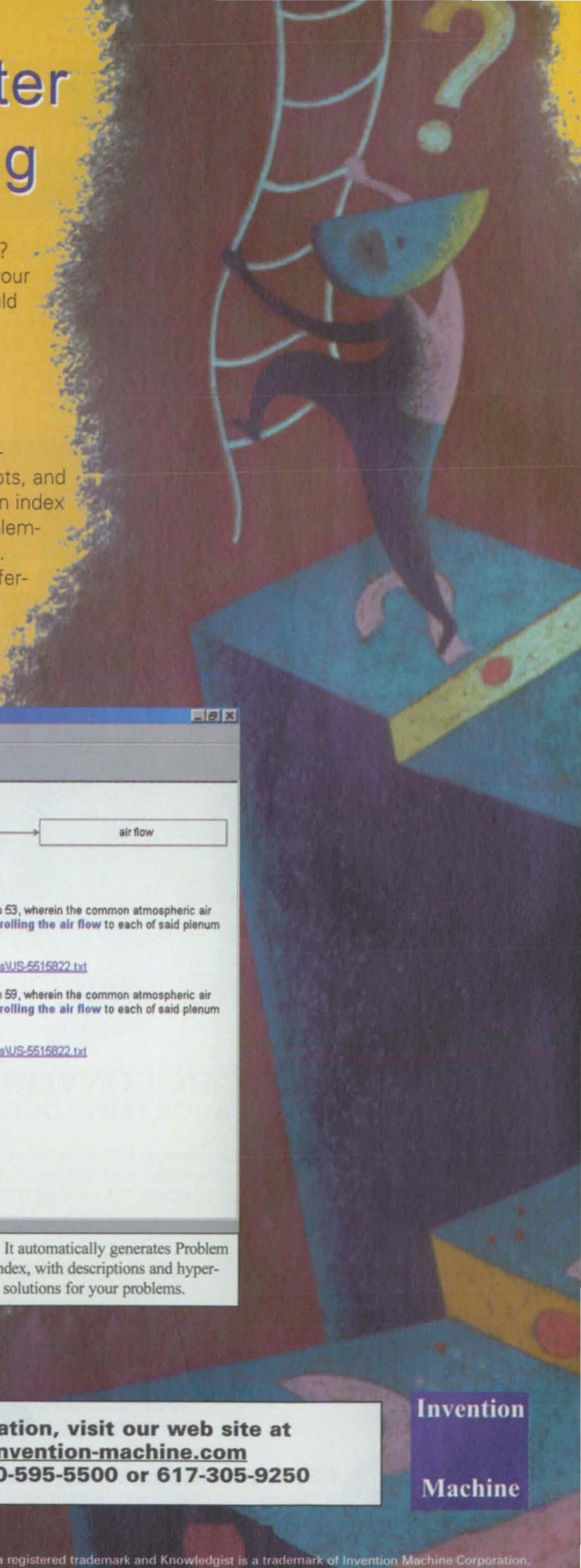
Stoica: I believe EHW has the potential to revolutionize technology in several domains. These range from communications, household appliances, and Internet, to micro/nano-scale systems and biological/artificial hybrids. There is great potential for commercial communications applications, such as data compression, reconfigurable antennas, and adaptive signal processing. For example, evolutionary techniques were shown to outperform current best techniques in image compression.

Reconfigurable hardware will play an increasing role in the Internet infrastructure, allowing the possibility of hardware adaptation. EHW could also be related to "smart households" — appliances that learn the behavior of the user and adapt to it. Some small part of the electronics within a refrigerator might interface with the Internet and connect with reconfigurable sensors that adapt themselves to the input signals of the environment.

Potential micro/nano-scale applications for EHW include miniature complex sensing, diagnosis, and monitoring systems. The future "lab on a chip" would perform adaptive detection of chemical and biological materials. These systems could be used in food preservation, virus and bacteria detection, and adaptive medication dosage.

A full transcript of this interview is available at www.nasatech.com. Contact Dr. Stoica at adrian.stoica@jpl.nasa.gov.

Let The Computer Do Your Reading



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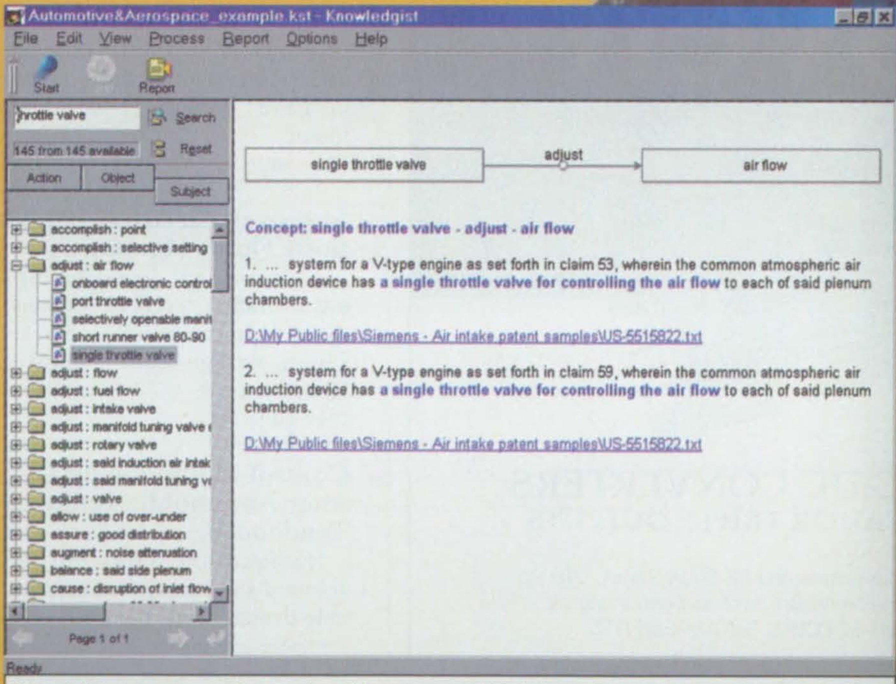

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For More Information Circle No. 540

Commercialization Opportunities

Interferometric System Images Small Vibrating Structures

The basic optical instrument is a low magnification microscope combined with a Michelson interferometer. The instrument is used for imaging vibrating electromechanical structures.
(See page 30.)

Microwave Battery Charger

A simple microwave power-transmission system is proposed for maintaining charged batteries in spacecraft immediately prior to launch. This concept could be adopted by emergency systems that have to be kept in a high state of readiness.
(See page 43.)

Susceptor-Coating Materials for Growth of 4H-SiC

Several materials are showing promise. This development is important for future electronic devices that will operate at power and temperature levels beyond those of the present Si- and GaAs-based devices.
(See page 46.)

Failure-Resistant Multiline Tethers

These improved tethers, originally developed for protecting satellites from orbital debris, can be adapted to climbing gear, suspension bridges, and towering cables.
(See page 50.)

Determining Glucose Levels From NIR Raman Spectra of Eyes

This noninvasive method is faster and involves less laser power than the earlier efforts based on Raman scattering to measure glucose concentration in blood.
(See page 52.)

Improved Electrical-Impedance Body Fluids Monitor

An instrument developed for measuring hydration levels in humans during space flight can be adapted by hospitals, clinical facilities, and medical research laboratories.
(See page 54.)

Control Methodology To Alter Automobile Rollover Tendencies

Hardware and software are being developed for incorporation into a variable-dynamics testbed vehicle to evaluate the dynamic characteristics of crash avoidance of a four-wheel land vehicle. The results will be used to improve safety with such active controls as increasing the stiffness of antiroll bars on tight turns.
(See page 62.)

Ultracapacitors Store Energy in a Hybrid Electric Vehicle

A hybrid electric transit bus has been developed that uses capacitors instead of batteries to store energy. The capacitors are viewed as superior to batteries in several respects.
(See page 63.)

Video Windowing Systems: Effective Display of Multiple Image Sources

The use of multiple windows shown simultaneously on a single display as a methodology for efficient conveyance of computer-based information is about as ubiquitous as the automobile. Since its origin in experimental computers at Xerox Park, the idea has been extended to allow windows to display images from multiple different sources, ranging from video cameras to high-resolution computer workstations.

Among the many applications for video windowing are real-time information displays for command and control systems, and for simulation. In command and control, tactical operators frequently need to monitor several video and computer sources simultaneously. The operator's ability to effectively absorb and analyze the data is enhanced when it is combined onto a single display, rather than spread out across an array of screens. Often, the space-saving aspect of a single, combined display versus a multitude where each is dedicated to a single video source, is a great benefit in command and control environments.

In simulation applications, video windowing often is applied to recreate control panels in a virtual display. Image generators provide instrumentation screens and other computer-generated imagery. Video sources present pre-recorded visual data. The multi-input display processor brings all the elements of the simulator together, digitally mixing the components to generate the final combined display.

The wide variety of signal sources that typically is present in such systems can represent a significant challenge to the system developer. This challenge can be met by implementation of a Window Display Processor, a device that provides a means to combine and control the input signal sources so that their windows can be individually and arbitrarily sealed and located on the display.

In an ideal world, all of the video inputs to a multiple window display system would adhere to a single standard that unambiguously defines electrical, logical, and temporal attributes of the video signal. Moreover, the signals would be phase-aligned to a single clock and all synchronization signals would occur at exactly the same time. Unfortunately, the real world isn't even close to this ideal situation.

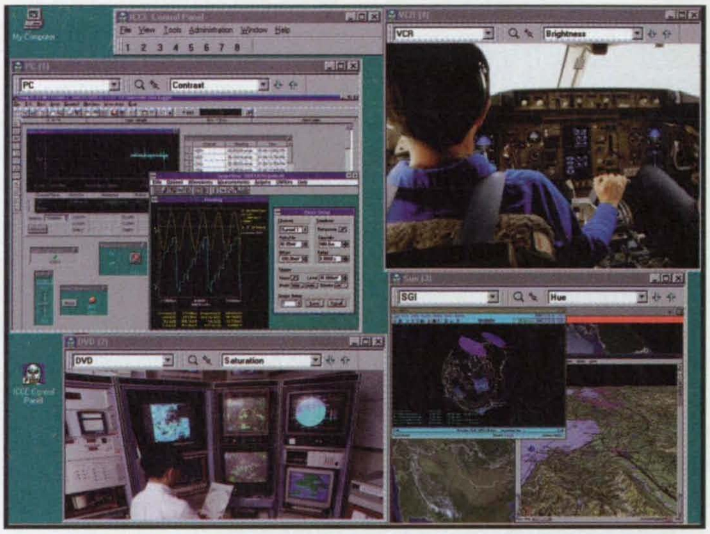


Figure 1. Integrated Control Center Environment (ICCE), developed by SM&A Corp., integrates audiovisual, multimedia, video, and multiple proprietary computer systems, all of which can be viewed and controlled via one or two monitors, one universal keyboard that re-maps to the various systems, and a mouse.

The inputs to a multiple window system will almost certainly be completely asynchronous to one another, and will most likely each have their own unique version of a synchronization scheme, often with nothing more than a vague nod to one of several standards that proliferate. The challenge, then, is for each input of the system to recognize the synchronization methodology of the system feeding it, extract the salient features of the horizontal and vertical synchronization signals in order to correctly re-sample the video signal, and subsequently store one or more frames of incoming video.

Synchronization and Sampling

An important capability of a configurable Window Display Processor is its ability to recognize the characteristics of an incoming signal so that it can synchronize it to a common timebase. This is important to ensure that a meaningful image is displayed in the associated window. This can be achieved by providing a user interface via which a system developer can provide the information for each connected signal. Unfortunately, too often the system developer does not have all of this information available, and it also can be a tedious process for a system with many inputs — a factor that is compounded if the system configuration is altered frequently. Thus, there is a requirement for "auto-syncing" capability in which the system monitors the inputs to sense and recognize an incoming signal.

This auto-syncing function is an iterative algorithm in which certain key characteristics of the incoming signal are measured (e.g. horizontal scan rate, sync, pulse width, etc.) and compared to a table of known sources. There is potentially an infinite number of permutations of computer graphics signals because, in addition to the various different sets of scan rate and blanking periods, horizontal and vertical synchronization information can be conveyed in a variety of ways (separate, combined, superimposed on the video signal).

Given the variety and large number of unique video signals, the auto-sync process may not always succeed in providing perfect alignment of a video signal within its window. In this case, an interactive user interface is provided for fine-tuning after an approximate match is made.

In order for multiple disparate signals to be displayed simultaneously, they must all be locked to a common timebase. In some applications, the common timebase is extracted from one of the input signals; in others, it is an externally provided signal with no associated image. In yet other applications, there is no externally supplied reference, and the common timebase is generated by the processing system.

Sampling and Line-Doubling

A sampling technique is used to capture the analog input signals, synchronize them to the common timebase, and extract the image information. The image information, once captured, can be scaled and organized into the correct destination window in the output frame store. The analog front end to the sampling engine detects the sync type and provides DC restoration clamps to ensure that each of the signals has a precise common reference. Any difference in DC level between red, green, and blue inputs will result in incorrect color sampling.

The analog front end also filters the incoming signals to satisfy the Nyquist sampling criteria, and thus avoid aliasing artifacts. If aliasing is allowed to occur, it results in multiple copies of the incoming signals overlapping in the frequency domain. Once sampled, these cannot be removed. The effect is highly visible on the resulting display, and manifests itself as an unpleasant horizontal distortion of vertical components of the image. In order to accommodate a large range of incoming signal frequencies, it is necessary to provide several filters that can be selected after the auto-sync function has determined the range of interest. If the filter's cutoff frequency is too low, it will result in a soft image, and if it is too high, it will result in aliasing artifacts.

Dealing with interlaced video signals requires special attention. In an interlaced system, a frame of video information is transferred as two fields. Each field comprises either the odd lines of the frame, or the even lines of the frame. The field frequency is twice that of the frame frequency. For example, in the NTSC system, fields are generated 60 times per second, but as two fields combine to make a frame, the effective frame frequency is 30Hz. In order to display the interlaced signal on a progressive scan monitor, the two fields must be combined. On the surface, it would seem that combining the two fields in a frame store could be achieved simply by providing field delays (Figure 3).

The problem is that the fields are temporally separated. The action captured in the even field occurred 17ms later than that captured by the odd field. An object moving swiftly across the field of view will be located in different places in the two fields, so the resulting combined frame will contain a distorted image as shown in Figure 4.

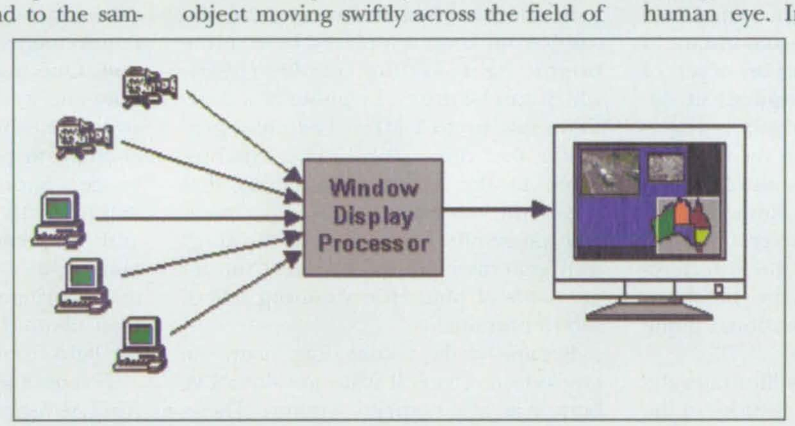


Figure 2. The Window Display Processor

This disturbing visual effect is referred to as a "motion artifact" and is highly perceptible with live video sources containing motion. Edges of objects moving horizontally will become feathered. Its effect on individual viewing ranges from mildly annoying to disturbing. The motion artifacts become exacerbated by the interpolative scaling that is used to zoom the video signal up or down to fit its destination window.

A simple and inexpensive compromise can be implemented for applications where motion artifacts cannot be tolerated but field, rather than frame, vertical resolution is acceptable. In this case, each line in a field is replicated to create a pseudo line-doubled, full-frame sized image. This has the disadvantage of having only half the vertical resolution, which results in a lack of clarity in the displayed image. The best results are obtained from deinterlacing techniques that employ sophisticated digital filtering to interpolate missing lines within each field.

Different video systems utilize different methods for encoding color information. In the early days of television, it was important to conserve bandwidth, so encoding techniques were developed that weighted the color information in the signal to match the sensitivity of the human eye. In these systems, chroma (or color) information in video signals is conveyed separately from luminance information (Y/C). There are various different methods of encoding color, referred to as color space. Computer graphics systems convey information in terms of primary color intensity (Red, Green, and Blue values) — yet another color space. A windowing system will need to convert the color spaces of all incoming signals to that of the output display — usually RGB.

For most "command and control" and "simulation and training" applications, the critical features of a Window Display Processor are flexibility in input signal processing (the ability to manage a wide variety of video types and signal rates) and flexibility in window management — giving the system designer total control over window size, position, and priority (stacking).

This article was written by Tim Elsmore, VP Engineering, at RGB Spectrum, Alameda, CA. For more information, call 510-814-7000, or visit www.rgb.com.

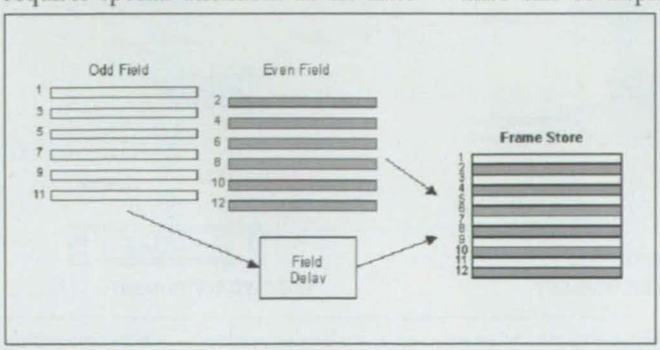


Figure 3

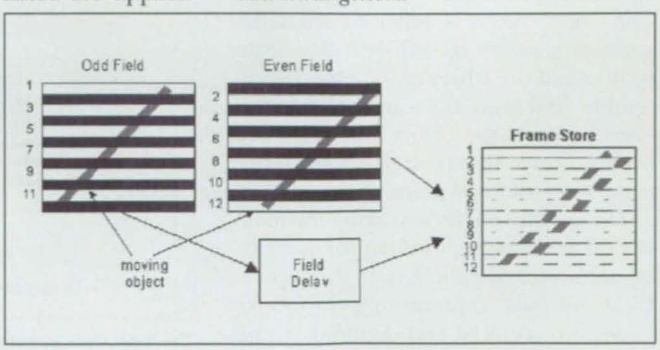


Figure 4

Special Coverage: Imaging/Video/Display Technology

Interferometric System Images Small Vibrating Structures

Stroboscopic interferograms depict surface profiles at selected phases of vibration.

NASA's Jet Propulsion Laboratory, Pasadena, California

A commercial scanning imaging white-light interferometer designed for measuring surface profiles of stationary objects has been modified into an interferometric instrument for imaging vibrating microelectromechanical structures. The modified instrument operates in a stroboscopic mode, generating a set of interferograms at a selected instant in the vibrational cycle. A number of sets of interferograms can be acquired at different instants of time corresponding to small increments of phase through the vibrational cycle so that the resulting collection of interferograms shows how the shape of the vibrating surface changes during the cycle; thus, the interferograms yield information on the shape and amplitude of the vibrational mode or modes.

The figure schematically illustrates the unmodified and modified versions of the instrument. The magnified image of the specimen is brought to focus in a charge-coupled-device (CCD) camera oriented along a main (vertical) optical axis. In the unmodified instrument, an incandescent lamp generates white light, which is reflected down along the main optical axis by a beam splitter. The microscope objective assembly contains another beam splitter, which divides the illumination into two beams: a reference beam sideways to the main optical axis and an object beam, which continues down along the main optical axis, through the objective lenses, and onto the specimen.

The reference beam is reflected from a flat mirror, then reflected from the beam splitter in the objective assembly back up the main optical axis toward the camera. The object beam is reflected from the specimen, passes up through the beam splitter and the lenses in the objective assembly, and into the camera. Interference between the object and reference beams forms the desired interference pattern on the focal plane of the camera.

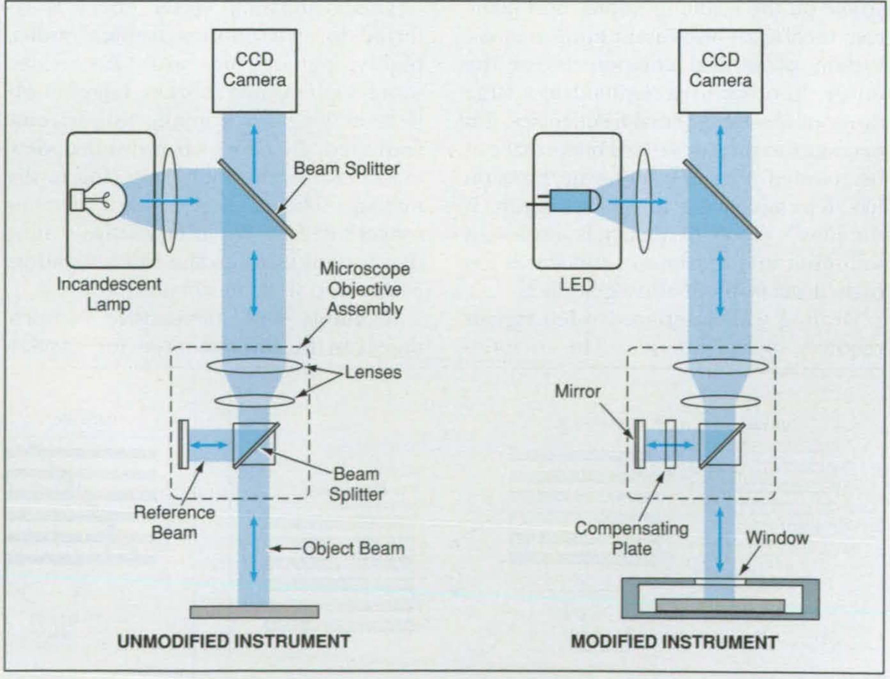
The specimen is moved along the main optical axis, passing through the position of zero optical-path-length difference. CCD outputs representing interferograms are acquired and digitized at various increments of optical-path-length difference. Then by use of special-purpose software, the digital interferograms are used to compute the surface profile of the specimen. The unmodified instrument cannot be used to obtain the surface profile of a vibrating specimen because the vibration blurs the interference patterns.

In the modified instrument, the incandescent lamp is replaced by an ultrabright light-emitting diode (LED), which can be driven by pulses at a repetition rate up to 2 MHz. The pulse generator that drives the LED is synchronized to the function generator that drives the vibrations of the specimen. The phase-offset capability of the function generator is used to select the increments of phase for acquiring sets of interferograms.

Because of the viscous drag, many microelectromechanical structures do not vibrate in air at atmospheric pressure. Therefore, in the modified instrument, the specimen is mounted in a small vacuum chamber and observed through a window. To compensate for the optical path length through the window, the modified instrument includes a plate of the same optical thickness as that of the window inserted in path of the reference beam.

With the modified instrument, vibrational displacements along the main optical axis can be measured with resolutions of the order of nanometers. The only fundamental limitation of the modified instrument lies in the competing requirements for stroboscopic illumination: One must generate enough luminous energy during each pulse to obtain an image, while keeping the pulse short enough, to prevent motion blur of the image. "Short enough" as used here is defined with respect to the amplitude and frequency of the vibration and means, specifically, that the displacement during the pulse must be no more than about 1/20 of the wavelength of the light from the LED.

This work was done by Roman Gutierrez, Kirill Shcheglov, and Tony K. Tang of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP) free on-line at www.nasatech.com under the Physical Sciences category.*
NPO-20177



The **Basic Optical Instrument** — in both the unmodified and modified versions — is a low-magnification microscope combined with a Michelson interferometer.

Four-Message Electromechanical Display System

The conventional limit of three messages could be overcome.

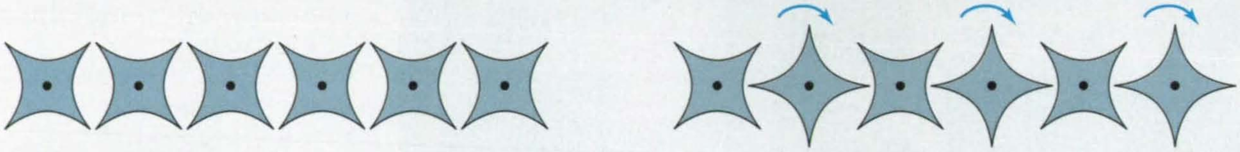
Marshall Space Flight Center, Alabama

A proposed electromechanical display system would be capable of presenting as many as four different messages. Conventional electromechanical display systems are limited to three messages.

The three-message limit arises as follows: A typical electromechanical display system contains display elements with multiple flat faces that are rotated into view to present a message. Each display element could show, for example, a letter or number or part of an image. If the display elements have flat faces, then the number of messages is limited to three because three is the maximum number of sides of a polygon that can be placed contiguously with other, identical polygons along a common base line and that can be rotated without interfering with an adjacent polygon.

In the proposed system, each display element would have four concave cylindrical faces shaped so that the elements could be positioned contiguously on a display plane, yet could be rotated without mechanical interference with adjacent elements (see figure). Because of the curvature of the faces, messages could be partially visible at greater (in comparison with flat faces) angles off the perpendicular to the display plane.

There is one "catch": To prevent mechanical interference while a display element is being rotated, an adjacent display element must either remain stationary or else be rotated in the opposite direction with a 45° lag. This "catch" can be turned to an advantage in that one can select from a variety of allowable sequences to draw attention to the display. For example, display elements could be rotated one at a time in any sequence, or the odd-numbered elements could be rotated while the even-numbered ones were held stationary, and vice versa.



Each Display Element Would Have Four Faces, each showing part of a different message. The concavity of the faces is what makes it possible to use four faces (instead of the conventional three) in an unbroken display field: If the faces were flat, then it would be necessary to mount the display elements with gaps between them to prevent interference during rotation.

This work was done by Richard T. Howard of **Marshall Space Flight Center**.

This invention is owned by NASA, and a patent application has been filed. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at (256) 544-5226 or sammy.nabors@mfs.nasa.gov. Refer to MFS-31368.

Rapid-Prototyping Virtual-Reality Software Tool Kit

The user need not engage in a tedious learning process.

Lyndon B. Johnson Space Center, Houston, Texas

The VrTool computer program enables its user to rapidly develop a prototype virtual-reality (VR) application program. Users of VR application programs need software that can help them keep pace with the rapidly evolving VR field. None of the previously commercially available VR software tool kits affords rapid-prototyping capabilities because all require users to generate their own code. This makes it necessary for users to engage in a tedious learning process to gain understanding of the application-program-generation process, which is also tedious.

VrTool offers a high-level user interface that makes it unnecessary for its user to engage in a tedious learning process; only minimal amount of learning time is necessary, and so the user can begin creating a VR environment almost immediately. As far as is known, no previously commercially available VR program offers a user interface that gives the user such a capability. The VrTool software would benefit any industry in which VR applications are used for simulations; examples of such industries include the aerospace, education, and medical industries.

VrTool includes four components: (1) a controller, which controls all other VR processes; (2) a renderer, which displays graphical information; (3) a collision-detection processor, which determines whether there are collisions among objects; and (4) a user-interface subprogram, which builds the VR scene. VrTool was developed for Silicon Graphics workstations and includes drivers for VR peripherals.

This work was done by J. Mark Voss of the Lincom Corporation for **Johnson Space Center.**

MSC-22693

Imaging With a Focal-Plane Array of Ultrasonic Transducers

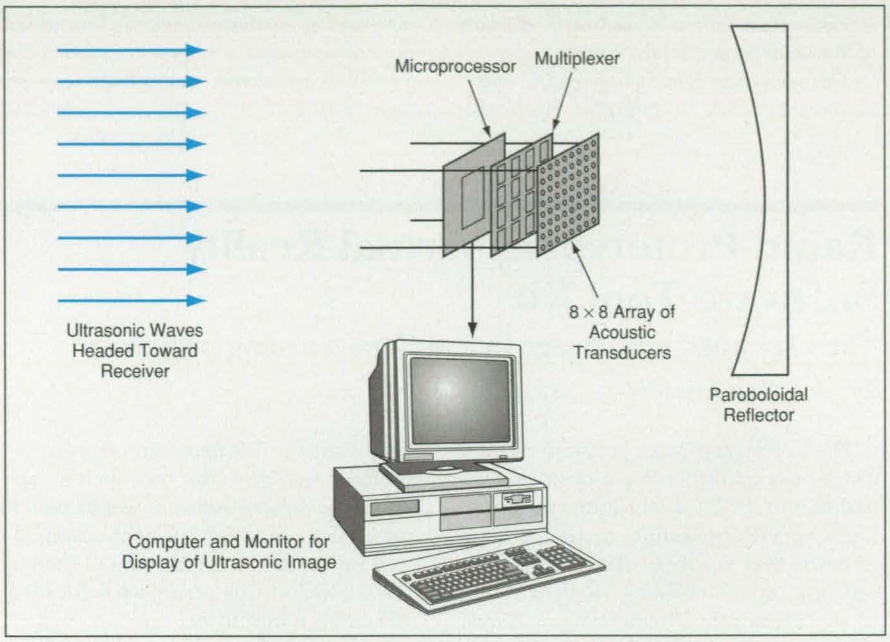
Phenomena that can be imaged include gas leaks, moving objects, and thermally induced air currents.

John F. Kennedy Space Center, Florida

A prototype system for acoustic imaging of gas leaks that emit ultrasound was developed at Kennedy Space Center. Potential government and commercial users concerned with leak imaging and safety expressed interest in this technology.

The prototype system includes an 8×8 array of air-coupled acoustic transducers with a peak-response frequency of 40 kHz. As indicated in the figure, the array is placed at the focal plane of a paraboloidal reflector (see figure) with a focal length of about 1 ft (30 cm). Thus, the array functions analogously to focal-plane arrays of photodetectors for imaging optical sources or focal-plane arrays of antenna elements for imaging radio sources, the unique feature of this array being that it provides a low-resolution image of acoustic sources in its field of "view."

The output signals from the transducers are buffered out serially through a 64-to-1 multiplexer, then sent to a microprocessor that includes an analog-to-digital converter. The microprocessor controls the operation of the multiplexer and sends the digitized, processed transducer outputs to a computer, which generates a real-time video display in which the intensities of the acoustic signals are represented by brightnesses in the cells (in effect, acoustic pixels) of a square 8×8 grid corresponding to the transducers. By use of a pixel-to-pixel-averaging algorithm, the pattern can be converted to one of 15×15 acoustic pixels with blocky appearance of the grid



A Square Array of Acoustic Transducers at the focal plane of a paraboloidal reflector puts out signals that can be processed to form a crude image of a distant source of ultrasound.

softened somewhat to give an appearance of finer resolution.

As described thus far, the system operates in a passive mode, in which it produces intensity images of leaks or other sources of high-pitch sound. However, the system also offers the more-powerful capability of operation in an active phase-imaging mode, in which the scene is "illuminated" by an ultrasonic signal of specified frequency and phase. Because the microprocessor has access to the phase as well as the magnitude or intensity information for each ultrasonic pixel, it is a relatively simple matter to process the transducer outputs to obtain an image in which the brightness of each ultrasonic pixel represents the difference between the phase of the "illuminating" signal and the signal returned to the corresponding transducer.

Phenomena that alter the speed of sound and thus the phase of the return signal can be imaged in this mode. Tests of the prototype system in the active phase-imaging showed it to be capable of imaging gas leaks, a cold airflow, and moving objects. It should also be possible to image fires and temperature gradients in still or moving air.

Recent improvement included the following:

- Preventing the receiver from being overwhelmed by near-field reflections of the transmitted signal;
- Increasing the resolution by increasing the number of transducers, along with the size of the reflector and/or the frequency; and
- Designing alternative systems with wider fields of view.

This work was done by William D. Haskell, James P. Strobel, Robert C. Youngquist, John S. Moerk, and Robert B. Cox formerly of I-NET for **Kennedy Space Center.**

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Two-Photon Microscope Imaging Spectrometer

Overlapping spectra from fluorescent-dye probes could be separated.

NASA's Jet Propulsion Laboratory, Pasadena, California

A two-photon microscope imaging spectrometer has been proposed for use in scanning confocal two-photon microscopy. The proposed instrument would solve a spectrum-overlap that sometimes arises, as explained below.

Scanning confocal two-photon microscopy is a variant of fluorescence microscopy, in which fluorescent dyes

are used as probes for selective monitoring of biological compounds and cells. In scanning two-photon confocal microscopy, a specimen is raster-scanned by a laser beam that is focused into the specimen through the objective lens of a microscope. Fluorescent light excited by two-photon absorption is collected by a photodetector. Light is collected from each pixel, then the output of the photodetector is digitized and stored. This process is repeated for all the pixels in the raster scan, thereby building up a digitized image that represents an "optical section" that is, in effect, a fluorescence cross section in the focal plane. Further repetition of the process on a succession of closely spaced focal planes yields three-dimensional image data.

If multiple dyes with overlapping fluorescence spectra are used, then one is faced with the problem of how to separate the individual fluorescence images, each of which reveals a different aspect of the structure and function of the specimen. The problem could be solved by processing image data acquired by the proposed two-photon microscope imaging spectrometer. The fluorescence-image data generated by this instrument would be resolved not only spatially but also spectrally; that is, a spectrum would be acquired for each pixel. If the spectrum of each pixel were a sum of overlapping, known fluorescence spectra, then by use of previously developed spectral-data-processing techniques, the intensity of each fluorescence spectrum (and thus the abundance of the corresponding dye in the pixel) could be computed.

In one version of the proposed instrument, a tunable filter (e.g., a liquid-crystal tunable filter) would be placed in front of the photodetector and would be tuned across the wavelength range of interest to acquire a spectrum for each pixel. One potential disadvantage of this version is that the spectrum-acquisition time could be long enough that one or more fluorescent dye(s) in the specimen could become photobleached during the concomitant long exposure to the laser beam used to excite the fluorescence. A second major problem is that the data acquisition time is too long for many biological problems.

A second version of the instrument would operate with a shorter exposure time per pixel, and thus less photobleaching. In this version, the fluorescent light from each pixel would be focused onto the entrance slit of a spectrometer. Inside the spectrometer, the light would be dispersed by wavelength along a linear array of photodetectors. To obtain sufficient sensitivity to acquire the spectrum for each pixel in a sufficiently short time, the array of photodetectors would likely have to consist of multiple photomultiplier tubes, a multielement photomultiplier tube, or an intensified charge-coupled-device (CCD) array.

This work was done by Gregory Bearman, Scott Fraser, and Rusty Landsford of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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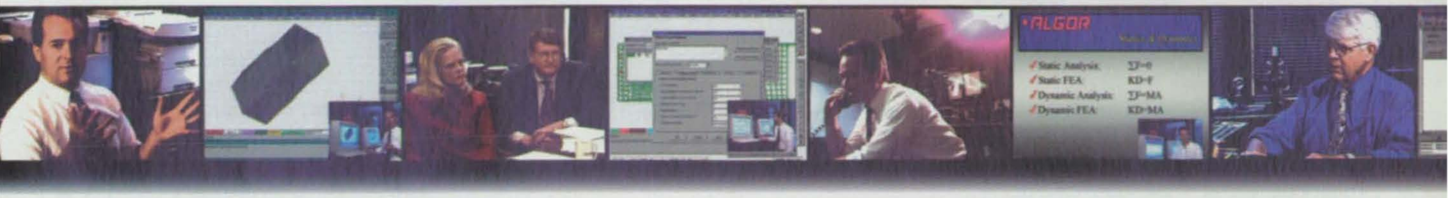

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The SVB-10 **digital video card** from Sony Precision Technology America, Lake Forest, CA, enables the user to consolidate a video camcorder, VCR, and tape recorder into one integrated system. Up to eight hours of MPEG2 digital video, along with analog signals or digital data streams, can be recorded and stored in a single Advanced Intelligent Tape (AIT) cartridge, which uses data cartridges the size of 8-mm video cassettes.

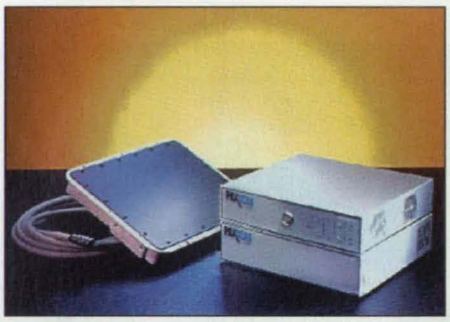
When installed in a Sony SIR-1000 Series data recorder, the video card allows users to record and reproduce analog measurement data and video imagery simultaneously. Test data can be reviewed visually in normal, slow/fast, and still picture, while replaying recorded analog or digital data. The card is designed for applications such as R&D, quality control, failure analysis, and vehicle simulation.

For More Information Circle No. 715

RGB Spectrum, Alameda, CA, has introduced the SynchroMaster® 450 **synchronous matrix switcher** with an internal video scaler. The multimedia system allows users to switch seamlessly between multiple video and computer signals. It offers user-programmable output timing, and presents an unbroken sync signal to a projector, regardless of the signal source.

The switcher accepts any computer signal up to 1280 x 1024 screen resolution, and video signals including NTSC, PAL, and CCIR 601 digital serial video. The system also accepts up to four computer and/or video signals directly. It is an external, standalone system with control via a front panel or RS-232 port. It also can be run from an external computer using an application program that mimics the front panel.

For More Information Circle No. 716



Varian Medical Systems, Palo Alto, CA, offers the PaxScan 4030 and PaxScan 2520 amorphous silicon **flat-panel imaging systems**. The 4030 is a 40 x 30-cm digital radiographic panel for applications requiring single-frame acquisition rates and a large field of view. Applications include non-destructive testing, quality control, and circuit board inspection.

The 2520 is based on an amorphous silicon detector array, and is available in several configurations for interfacing with x-ray based imaging systems. A software tool kit is included with the 2520 for facilitating installation. The imaging systems come in a high-voltage configuration for operating at energy ranges to 1000 kV.

For More Information Circle No. 714

MicroImage Video Systems, Boyertown, PA, offers the ENC400 RGB-to-NTSC video and S-Video **encoder** for industrial video applications such as recording the signal from a camera that does not produce NTSC video or S-Video signals. The color subcarrier is locked to the horizontal frequency using phase-locked loop techniques. High-signal bandwidth is maintained on both the Composite and S-Video outputs.

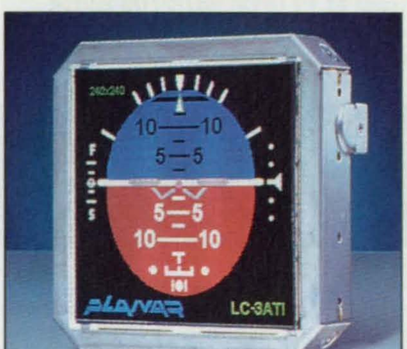
The unit is compatible with video sources that generate 0.714Vpp analog RGB video and operate close to 15.734Khz horizontal frequency. RGB inputs and NTSC video output are standard BNC connectors; the S-Video output is a standard pin mini-DIN type. Power is supplied by a 12 VDC wall plug transformer. An available rack-mount version has a built-in power supply and includes a detachable power cable.

For More Information Circle No. 719

The LQ-D100 DV Med™ DVD-RAM **digital still-picture recording/playback device** from Panasonic Industrial/Medical Group, Secaucus, NJ, is a digital disc recorder/player that provides recording and playback of high-quality, uncompressed still images. The printer-size footprint and video input allow users to replace analog printers with a digital recorder.

DVDs recorded on the device can be viewed and archived on virtually any PC with a DVD-RAM drive, when used in conjunction with image-viewing software. The device is designed for standalone operation or for assimilation into a variety of application-intensive imaging systems. Applications include medical, non-destructive testing, test and measurement, and inspection.

For More Information Circle No. 718



The 3ATI AMLCD active matrix **liquid crystal display** from Planar Systems, Beaverton, OR, is designed for applications in commercial and military aircraft, including flight deck instruments such as engine information centers, attitude direction indicators, and horizontal situation indicators. The ruggedized, color display is standard instrument size.

The display features an operating temperature of -30 to +85° C, and has a storage temperature to +90° C. It features a 240 x 240-pixel matrix in a quad-pixel (red, green, white, and blue) format. The video-capable response rate displays information in real-time and in full color.

For More Information Circle No. 717

Improved HRTF-Based Pseudostereophony

Monaural signals are filtered digitally to obtain pseudostereophonic output signals.

Ames Research Center, Moffett Field, California

An improved pseudostereophonic system utilizes digital filtering and head-related transfer functions (HRTFs) to afford tailorability and sound quality not available from older pseudostereophonic systems. Although the term "pseudostereophony" may not be widely known, the underlying concept has been studied and applied for more than four decades. Pseudostereophony is a family of techniques for deriving right and left channels of sound from a single-channel (monaurally recorded) source to give the listener an impression of sound coming from more than one direction.

The pinnae of human ears affect entering sound in a way that varies with the direction of incidence and thus gives the brain cues to the location of the source. These cues are in addition to the directional cues provided by differences between the times of arrival of signals. The effects of the pinnae can be quantified by HRTFs. In the time domain, an HRTF is an impulse response, as a function of direction of incidence, that is convolved with the incident acoustic signal. In the frequency domain, the HRTF is a magnitude and phase response, as a function of frequency of sound and direction of incidence, that multiplies the frequency-domain complex-amplitude representation of the incident acoustic signal.

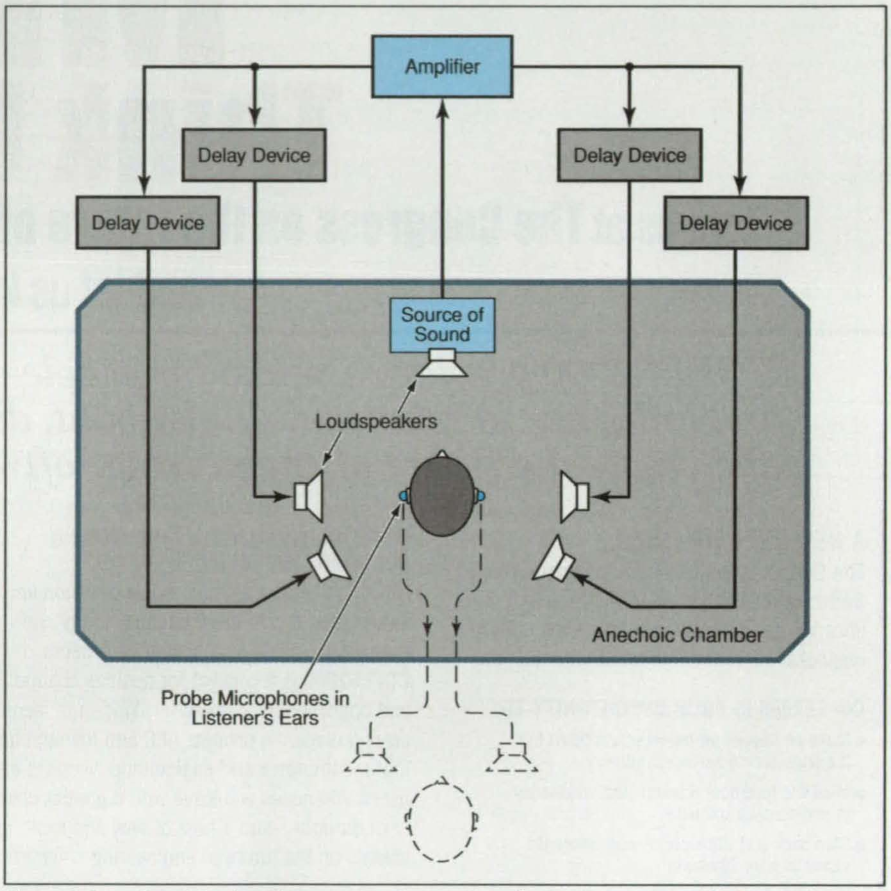


Figure 1. **Sounds Arriving in a Listener's Ears** from various directions are measured, then used to compute head-related transfer functions.

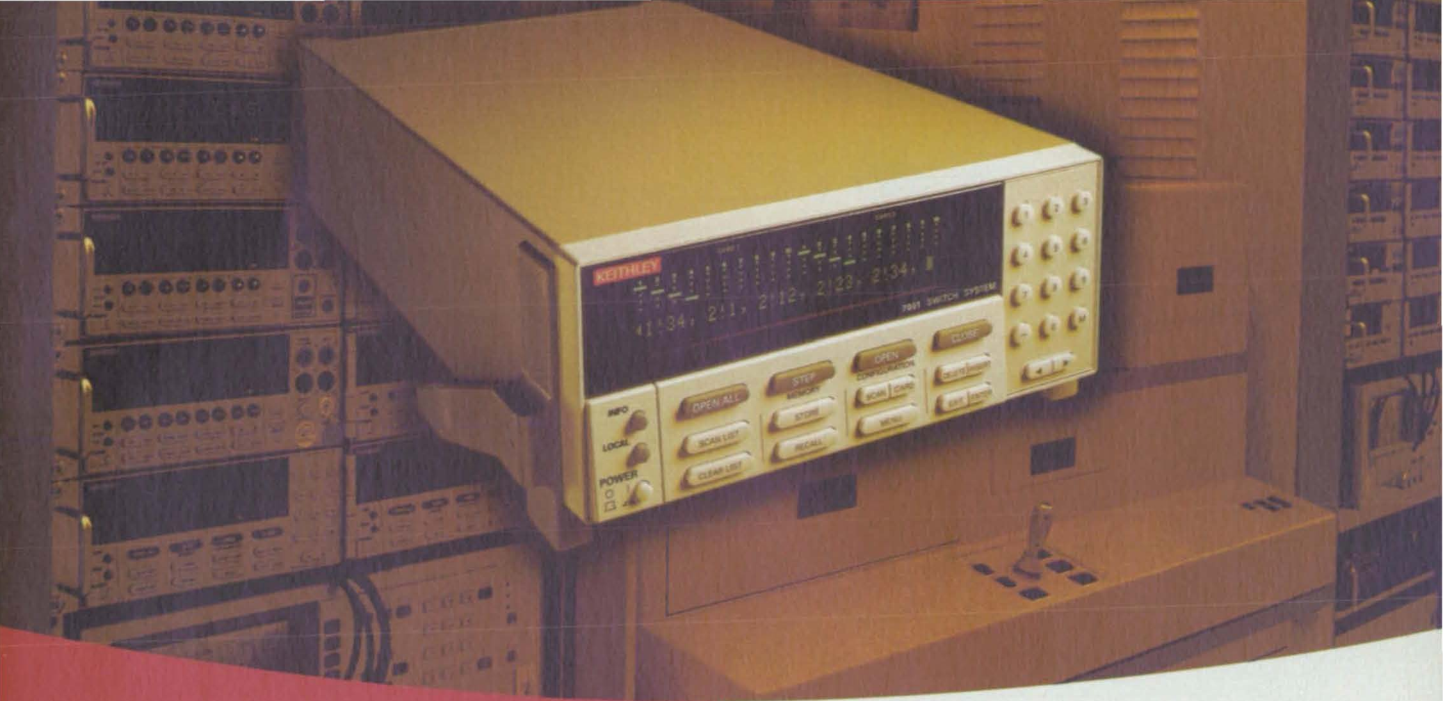
The present pseudostereophonic system utilizes HRTFs in the following way: First, the HRTFs of an average human listener are determined experimentally. Thereafter, the digital HRTFs are used, along with delays and optional filtering functions, to digitally synthesize right- and left-channel signals that make a listener perceive the sound as coming from multiple sources in different directions.

Figure 1 depicts an apparatus for measuring HRTFs for five directions of incidence. A human listener sits in an anechoic chamber, with a loudspeaker at ear height directly in front (azimuth 0°) and four other loudspeakers at ear height at azimuths of 90, 120, 240, and 270°. A source of sound is connected to the loudspeaker at 0° and is connected to the other loudspeakers through an amplifier and delay devices. Small probe microphones in the listener's ears measure the entering sound. In principle, as indicated by the dashed lines, the outputs of the right and left microphones could be simplistically fed to right and left loudspeakers, respectively, to generate sounds with perceived directional characteristics. However, instead, the sounds measured by the microphones are used to compute the HRTFs, which are then used in the pseudostereophonic system depicted in Figure 2.

A monaural input signal is fed to an analog-to-digital converter (ADC). The digital signal is distributed on six lines. Lines 1 and 6 couple the signal directly to left and right digital summing devices, while each of lines 2 through 5 passes through an individual digital delay device that corresponds to one of the nonzero azimuth angles. The delays of these devices differ and are set as described below.

The outputs of all the delay devices are multiplied by a common gain factor that can be adjusted by the user. Next, each delayed and multiplied signal is processed by a right and a left finite-impulse-response (FIR) filter that approximates the right and left HRTF, respectively, for the azimuth angle. The resulting left and right HRTF outputs are summed in the left and right digital summing devices, respectively. The summed outputs for the left and right channels are then passed through separate digital-to-analog converters (DACs) to the left and right loudspeakers, respectively.

The delays, gains, and FIR-filter parameters can be chosen to obtain desired psychoacoustic effects. For example, the



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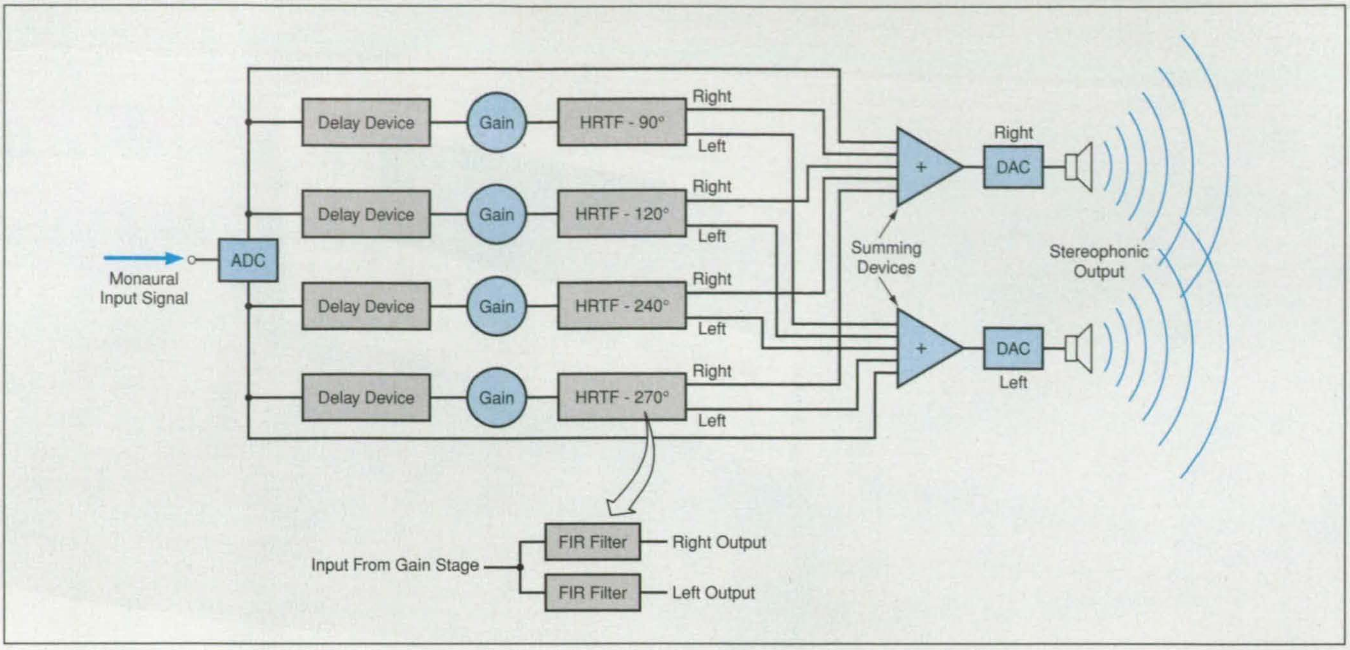


Figure 2. A **Monaural Signal Is Digitally Filtered** to synthesize right and left signals for a pseudostereophonic effect.

gain of the delayed signals on lines 2 through 5 can be set at 6 dB, in keeping with an empirical finding that this is the best gain for pseudostereophony with sounds of various types, including speech and music. Alternatively, the user can set the gain at zero for monaural listening, or can set the gain at >6 dB to obtain an exaggerated pseudostereophonic effect.

Criteria for setting delays are somewhat more complex. Parameters to be considered include (1) the interval between the undelayed sound and the first delay, (2) the intervals between succeeding delays, and (3) the time of the final delay, which depends on the previous delays. An important psychoacoustic consideration in choosing delays is that the signals remain below the level of echo disturbance; in this regard, the initial delay has been found to be the most important one. The intervals between successive delays should be within a range so that each delayed sound would not be heard as a separate sound. Typical acceptable values of initial delay are between 15 and 25 ms, and optimum intervals between successive delays are between 5 and 10 ms. In order for the use of HRTFs to yield a sensation of increased auditory spaciousness, the final delay should be at least 30 ms; this is consistent with findings from research into the effect of early reflections in concert halls.

Although the system as described thus far includes four delay and HRTF channels, it could also be constructed with more or fewer delay and HRTF channels. Other possible variations include the use of larger or smaller numbers of coefficients used to approximate the HRTFs in the FIR filters.

In comparison with older pseudostereophonic systems, this system generates sound that is less "colored"; that is, less altered in timbre. This system offers greater flexibility for synthesizing the sound at a wider range of listening positions. The two output channels of the present system can also be mixed to monaural output without disturbing coloration effects that result from phase cancellation. Moreover, the sound gives an increased impression of spaciousness because the two output signals are decorrelated. Yet another advantage is that multiple inputs with differential frequency responses can be distinguished from each other more easily in this system than in a monaural system.

This work was done by Durand R. Begault of **Ames Research Center.** *For further information, access the Technical Support Package*

(TSP) free on-line at www.nasatech.com under the Electronic Components and Systems category.

This invention has been patented by NASA (U.S. Patent No. 5,173,944). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center; (650) 604-5104. Refer to ARC-11919.

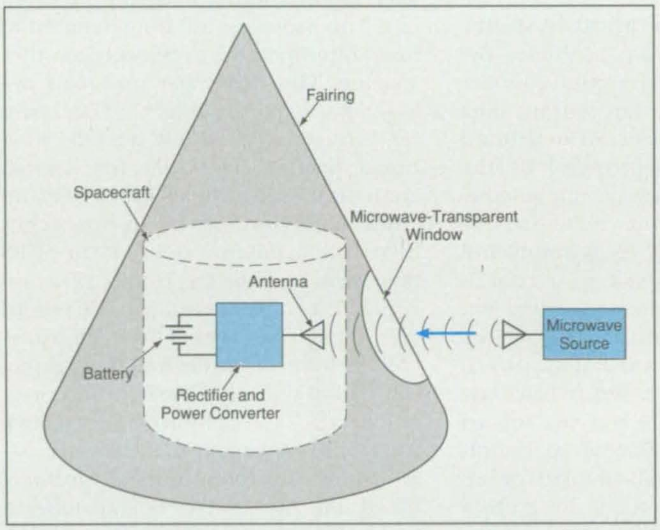
Microwave Battery Charger

Batteries would be kept charged without wire connections.

Goddard Space Flight Center, Greenbelt, Maryland

A simple microwave power-transmission system has been proposed for maintaining the charge on spacecraft batteries immediately prior to launch. The basic concept of this system could also be applied to other systems (e.g., emergency equipment) that must be kept in a state of high readiness for rapid deployment, without need for cable connections that could impede or slow deployment.

The umbilical cable that supplies power to a spacecraft on a launch pad must be disconnected at some prescribed time before launch. Once the disconnection is made, the spacecraft operates on battery power. The spacecraft must be launched before the battery discharges so much that the spacecraft could not be relied upon to function correctly. The launch must be canceled if the delay exceeds the allowable discharge time.



Microwave Power Would Be Rectified to dc power, which would be used to charge batteries.

The proposed system would make it unnecessary to cancel a launch on account of battery discharge. The system (see figure) would function as follows: Immediately before the disconnection of the umbilical cable, a microwave source would be turned on. The microwave beam from this source would be aimed at the spacecraft through a microwave-transparent window on the fairing of the launch rocket. An antenna on the spacecraft would intercept the microwave beam. A rectifier-and-power-converter circuit connected to the antenna would convert the received microwave power to dc power, which would be used to charge the spacecraft batteries.

This work was done by Richard Rolnicki of **Goddard Space Flight Center.** *No further documentation is available.*
GSC-13784

Software Interface Between MATLAB and a PC RS-232 Serial Port

A computer program establishes an interface between the MATLAB software and the serial data port of a personal computer (PC) that runs either the Windows 95 or the Windows NT operating system. The program makes it possible to utilize the graphical user interface (GUI) and the data-acquisition, control, and data-analysis capabilities of MATLAB while sending or receiving data via the RS-232 serial port. The data in question can be exchanged with external serial-communicating electronic circuitry, which could include another personal computer.

From the MATLAB command line or GUI, the user can initialize a serial-port session, cause the PC to write a byte to (or receive a byte from) the port, then terminate the session. The program provides a single command, "SerIO('x')," that acts in one of five different ways, depending upon which of four allowable values of the parameter x is specified:

- "SerIO('i')" initializes a Windows 95 or NT serial-port communication interface.
- Once initialization has been accomplished, "byte=SerIO('r')" utilizes a Windows 95 or NT kernel to read a single byte from the serial port and returns the value of the byte in "byte."
- "SerIO('w',byte)" utilizes the kernel to write the byte parameters to the serial port.
- "SerIO('d')" destroys the Windows 95 or NT serial-port handle that was created by "SerIO('i')" and used for reading and/or writing.
- "SerIO('?')" can be used to ask whether initialization has been performed.

An important feature of this program that helps to distinguish it from programs developed previously for the same purpose arises from the use of the Windows 95/NT kernel calls instead of direct inputs to and outputs from the hardware address of the serial port. This feature is advantageous in that it provides for a better behaved communication interface.

The program utilizes the Microsoft Visual C/C++ compiler in conjunction with the external-file-development capabilities of MATLAB. The program implements 4,096-byte transmitting and receiving buffers that enable communication between systems with varying transmission speeds. The program can readily be modified to return a vector of data (in contradistinction to a single byte) to the MATLAB software environment in order to accelerate or off-load MATLAB processing.

This work was done by Brandon Dewberry of **Marshall Space Flight Center.** *For further information, contact Larry Gagliano, MSFC Software Release Authority, at (256) 544-7175 or larry.gagliano@msfc.nasa.gov. MFS-31391*

Program for Analysis of Spacecraft Telecommunication Systems

A computer program facilitates the analysis and design of a radio-communication system for transmitting data from an orbiting spacecraft to ground stations. Input data provided by the user include primarily (1) parameters of the spacecraft orbit (including parameters that specify its position and orientation with respect to a coordinate system that translates with, but does not rotate with, the Earth); (2) either a specification of the gain pattern or else parameters needed to calculate the gain pattern of the antenna aboard the spacecraft; (3) type of spacecraft antenna aiming (nadir-pointed or articulated); (4) locations of the ground stations; (5) downlink bit rates and frequencies; (6) spacecraft instrument data rates; and (7) the angle (relative to the horizon) below which the line of sight from the spacecraft to each ground station is deemed to be blocked. The program calculates the spacecraft trajectory, the times when the spacecraft is visible from each ground station, the times (as functions of visibility and the antenna gain pattern) when radio communication is possible, the number of bits that a ground station can receive from the spacecraft during a given orbit, and the spacecraft data-storage capacity needed to hold data that are generated between communication intervals.

This work was done by Anil Kantak and Faiza Lansing of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Software category.*

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-20672

Software for Spacecraft/ Ground Communication via the Internet

The Space Communications Protocol Standards (SCPS) specify a developmental system of international protocols for data communications between spacecraft and points on Earth. SCPS protocols are intended to make a spacecraft appear, to a terrestrial computer user, as just another node on the Internet. The protocols are implemented to be as interoperable as possible to other systems. The SCPS file protocols are based partly on the Internet File Transfer Protocol (FTP), but include additional features necessary for smooth communication over channels that include interruptible Earth/spacecraft links; unlike the Internet FTP, the SCPS protocols provide for restart of interrupted file transfers and provide record read/update services. The SCPS protocols include (1) a file-handling protocol based on the Internet FTP, with modifications to optimize performance for typical spacecraft data streams; (2) an underlying retransmission protocol based on the Internet Transmission Control Protocol (TCP), with modifications to ensure reliability in the face of interruptions; (3) a data-protection protocol derived from a number of security protocols; and (4) a scalable networking protocol for routing of messages, based on the Internet Protocol (IP), with modifications to support space routing and increase communication efficiency.

This program was written by Eric Travis, Robert Durst, Patrick Feighery, and Mary Jo Zukoski of Mitre Corp. and by Steven Sides of SAIC for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Software category.*

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-20282.

Improved Fabrication of $YBa_2Cu_3O_{7-x}$ Superconductors

These superconductors are made from pressed powders of Y_2O_3, CuO, and $Ba(NO_3)_2$.

Marshall Space Flight Center, Alabama

An improved method of manufacturing high-temperature superconductors of general composition $YBa_2Cu_3O_{7-x}$ and various grain structures has been devised. This method involves mixing, pressing, and heating of Y_2O_3, CuO, and $Ba(NO_3)_2$ powders. This method is easier than an older method that involved mixing and sintering of Y_2O_3, CuO, and $BaCO_3$ powders followed by repeated grinding and sintering, followed by pressing to final size and shape.

In the present method, the first step is to mix commercial grade powders of Y_2O_3, CuO, and $Ba(NO_3)_2$ by percent by weight of the final mixture. Optionally, the powder mixture can be doped with a small proportion of silver (such doping results in, among other things, a higher-density final product). The powder mixture is placed in a die and pressed at either room temperature or an elevated temperature. Pressing densifies the powder mixture and forms a piece of approximately final size and shape.

Both cold and hot pressing yield similar results, though hot pressing is ordinarily preferable because it results in a piece that is denser and less delicate and thus easier to handle. The denser hot pressed samples also maintain closer to the final desired shape. In the case of hot pressing, care must be taken not to exceed the peritectic-transformation temperature-and-pressure range of the powders because, if such a transformation occurs, then the powders react prematurely with each other and/or react with the die.

The pressed piece is taken from the die and placed on a substrate of densified aluminum oxide or other suitable material in a furnace. The temperature-vs.-time schedule of the furnace can be altered to obtain desired results. The best results occur when the temperature of the pressed piece is heated slowly to 550 °C and held there for one hour before raising the temperature slowly to 650 °C. Thereafter, to obtain the desired grain structure and quality, the pressed piece can be treated by almost any temperature-vs.-time profile or post-sintering procedure (for example, annealing in oxygen) cited in any of the numerous patents and research papers that address the manufacture of $YBa_2Cu_3O_{7-x}$ high-temperature superconductors.

A piece of bulk superconductor made according to this method can be used as is, provided that it has the desired final size and shape. Alternatively, it can be processed further; for example, it could be ground into a $YBa_2Cu_3O_{7-x}$ that could be further pressed and sintered to final size and shape.

This work was done by Glen A. Robertson of **Marshall Space Flight Center.**

This invention is owned by NASA, and a patent application has been filed. For further information, contact Sammy Nabors at (256) 544-5226 or sammy.nabors@mfs.nasa.gov. Refer to MFS-31284.

Susceptor-Coating Materials for Growth of 4H-SiC

Better coatings are needed to obtain precise C/Si concentrations and minimize contamination.

John H. Glenn Research Center, Cleveland, Ohio

Several materials have shown promise for coating graphite susceptors used in epitaxial growth of 4H-SiC. The development of appropriate susceptor-coating materials is an essential part of continuing efforts to produce high-quality, thick, undoped and lightly doped epilayers of 4H-SiC for use as semiconductors in future electronic devices that will operate at power levels and temperatures beyond the limits of Si- and GaAs-based devices.

SiC grows in many different crystalline structures called "polytypes." 4H-SiC is one of these polytypes and is the preferred one for electronic devices because in comparison with other SiC polytypes, its charge-carrier mobility is greater and the anisotropy of its mobility is smaller. Epitaxial films of SiC are made by chemical vapor deposition (CVD) from carbon- and silicon-containing gas mixtures onto radio-heated susceptors. Heretofore, the most common susceptor materials have been graphite and SiC-coated graphite.

The input flows of Si- and C-containing gases into an SiC CVD chamber are well controlled by use of mass-flow controllers, but this does not always suffice to achieve the needed precise control of the proportion of C to Si: Both bare graphite and SiC-coated graphite susceptors are vulnerable to etching at the growth temperature (typically >1,350 °C) in the presence of H_2, which is one of the gases in a typical CVD gas mixture. Depending on the susceptor material and the particular CVD process, such etching releases uncontrolled amounts of C and/or Si into the CVD gas mixture, thereby giving rise to undesired changes in the structure, density of defects, and doping of the epilayer. Etching of a graphite susceptor can also release B, Al, and other impurities that can become incorporated into the epilayer as undesired dopants. Moreover, a bare graphite susceptor is porous and can trap a desired dopant during a CVD run, then release the dopant during a subsequent CVD run, in which the dopant could be undesired.

Thus, a graphite-susceptor-coating material that is much less vulnerable to etching is needed for growing high-quality 4H-SiC. A suitable material must have a coefficient of thermal expansion close to that of the underlying graphite, must adhere to the graphite

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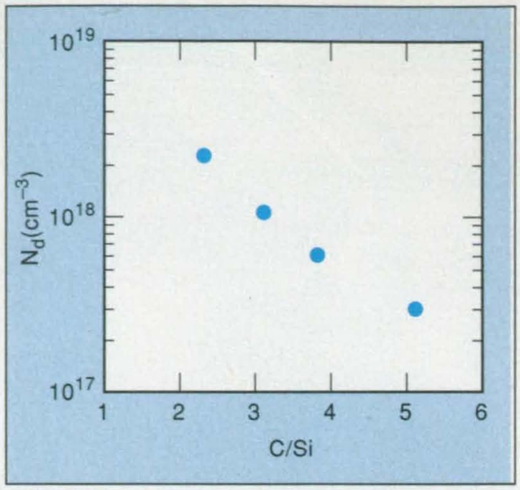
without flaking or chipping off during CVD, must be sufficiently thermally conductive to transfer heat from the susceptor to the growing epilayer, must be amenable to deposition in a layer thin enough not to obstruct coupling of radio-frequency energy to the susceptor, should have low porosity to prevent trapping of impurities, and should be as chemically inert as possible in the presence of hot H_2.

Four materials that satisfy these criteria to various degrees were selected as candidates for experimental evaluation. One of these materials was SiC, which as reported above, was already known to be vulnerable to etching. The other materials were carbon-based coatings, denoted as C1, C2, and C3. The C1 coating was used to establish an epitaxial-growth baseline for comparisons. The films grown with SiC-coated graphite susceptors were of poor quality in comparison with those grown on the C1-coated susceptors, and the SiC-coated susceptors were severely degraded, leading to the conclusion that SiC should be excluded from further consideration. On the other hand, the SiC films produced with the C2- and C3-coated susceptors were of high quality, and the doping control was demonstrated (see figure). The C2-coated susceptors exhibited no obvious degradation and appeared to have operational lifetimes longer than those of the baseline C1-coated susceptors. The C3-coated susceptors exhibited some chipping. These results suggest that these carbon-based coatings could be suitable for epitaxial growth of high-quality 4H-SiC.



A **4H-SiC Epilayer** was grown by CVD, using a carbon-based coating on a graphite susceptor. An 11.5-μm thick epilayer showed a smooth surface morphology, and n-type doping control via site competition epitaxy was demonstrated as shown.

This work was done by Barbara Landini of Advanced Technology Materials, Inc., for **Glenn Research Center.** *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16699.

Priming Ceramic Materials for Better Waterproofing

Precoating with silica facilitates the application of a waterproofing final coat.

Ames Research Center, Moffett Field, California

An improved process for waterproofing ceramic materials — especially lightweight ceramic insulation materials in both rigid (tile) and flexible (blanket) form — has been invented. In this process, traditional waterproofing agents are used, but before the waterproofing agents are applied, the ceramic substrates are first coated with thin layers of silica, as explained below.

As used here, "waterproofing" of ceramics means rendering them water-repellent, not making them impervious. In situations in which ceramics are exposed to water, the need for waterproofing arises as follows: These materials are very porous (void volumes exceed 90 percent in some cases). They are also hygroscopic — typically capable of absorbing three to five times their own weight of water. Water can thus add undesirably to the weight of these materials. These materials can also be damaged by explosive vaporization of trapped water during rapid heating, and by the anomalous expansion and contraction of trapped water during freezing and thawing. Thus, what is needed is a means to reduce the intrusion of water to minimize these deleterious effects.

The traditional waterproofing agents preferred for this purpose are silanes, substituted silanes, silazanes, and mix-

tures of these. These agents can be applied easily to silica ceramics, but cannot be applied easily to other (e.g., alumina) ceramics. The present invention is based on the discovery that even a difficult-to-coat ceramic can easily be coated with a traditional silicon-containing waterproofing agent, provided that it is first coated with a thin layer of silica. "Coated" as used here does not mean covered on the exterior macroscopic surface; it means covered on all microscopic exterior and interior pore surfaces and interstices.

The silica coating is formed by first coating with a silica precursor and converting the precursor to silica either in situ during the coating process or subsequently by oxidative pyrolysis. Some of the traditional waterproofing agents mentioned above are also useful as silica precursors; other silica precursors include silicones and siloxanes. A silica precursor can be applied to a ceramic substrate by any of a number of techniques; for example, solution coating, vapor deposition, low-pressure chemical deposition, immersion, or injection. The silica coating is typically thin enough (thickness of the order of 1 μm or less) to be flexible, so that it can be used on either a rigid or a flexible ceramic substrate without risk of cracking and consequent exposure of the ceramic to moisture.

In an experiment to demonstrate the invention, a piece of ceramic insulation containing alumina batting was coated by contact with methyltrimethoxysilane vapor (the silica precursor), then further coated with dimethylethoxysilane waterproofing agent. The piece was then heated in air at 1,000 °C for two hours, destroying the waterproofing and pyrolyzing the silica precursor to silica. The waterproofing agent was then reapplied. The waterproofed piece was found to absorb less than 5 percent of its weight in water — an acceptably small amount of water in the application for which this particular piece of insulation was designed.

This work was done by Domenick A. Cagliostro and Ming-ta S. Hsu of **Ames Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at*** ***www.nasatech.com*** *under the Materials category.*

This invention has been patented by NASA (U.S. Patent No. 5,814,397). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center; (650) 604-5104. Refer to ARC-14029.

Failure-Resistant Multiline Tethers

Secondary lines take up the slack when primary lines are severed.

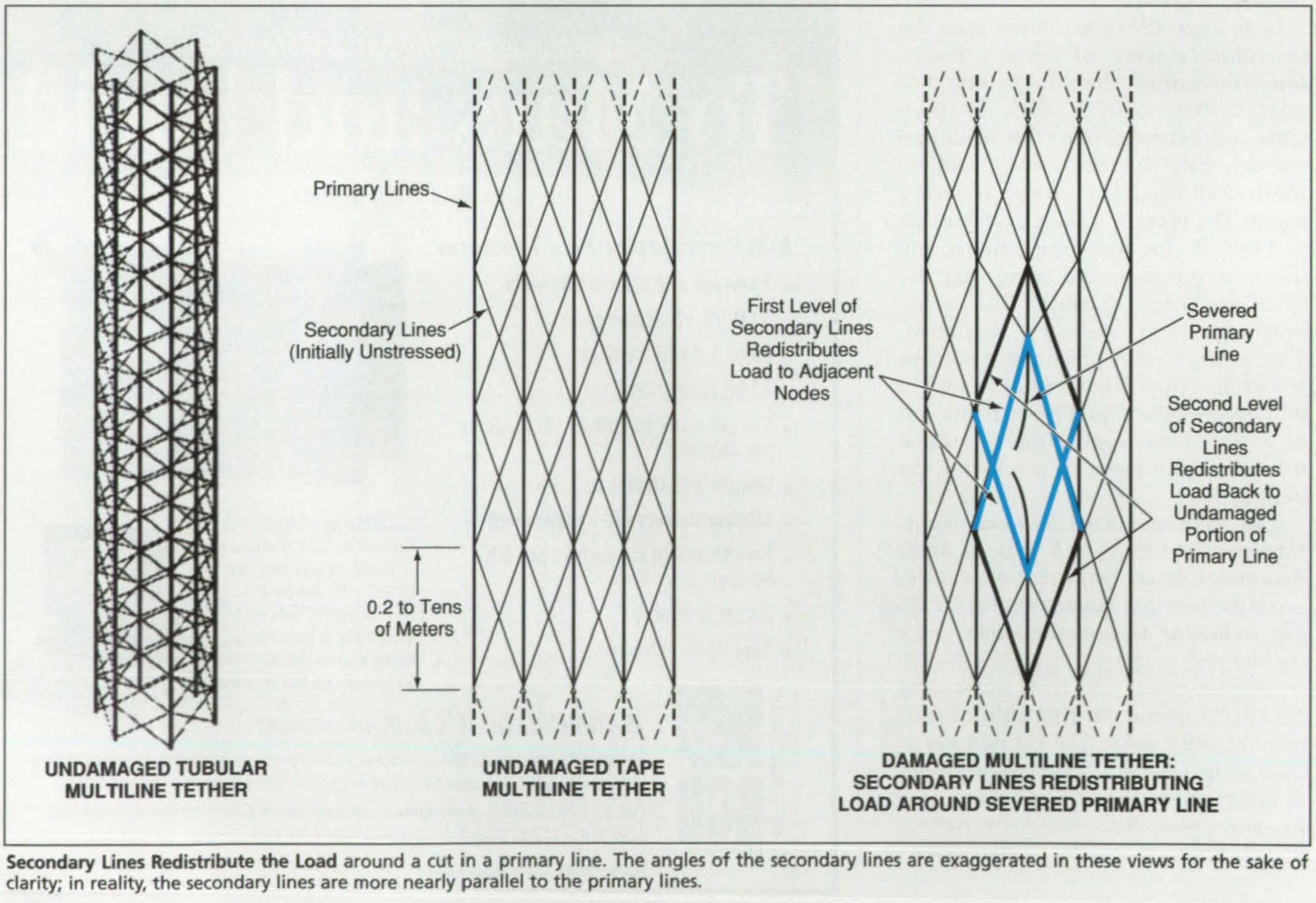
Marshall Space Flight Center, Alabama

Hoytethers™ are failure-resistant multiline tethers named after their inventor, Robert Hoyt. They were originally intended for use in outer space to provide reliable tethering of satellites in the presence of orbital-debris and micrometeorite impacts that can sever single-line tethers. Hoytethers™ may also be adaptable to terrestrial use as tensile structural members in situations in which high reliability is required, such as climbing ropes, suspension bridges, and towering cables.

The basic failure-resistant multiline tether structure (see figure) is an open net comprising primary and secondary lines that, together, provide redundant linkage. Each primary line runs the full length of the tether and is anchored at both ends on a ring or bar that enforces the circumferential spacing (for a tubular tether) or lateral spacing (for a tape tether). The primary lines are connected diagonally at regular spatial periods by the secondary lines, which are attached firmly by braiding, twisting, clamps or other knotless interconnection methods, so as not to slip.

The secondary lines remain slack as long as the tether is undamaged. When a primary line is severed, the secondary lines assume the tensile load and redistribute the load in such a way that the effects of damage are localized to the vicinity of the cut. Although the secondary lines are diagonal, they lie nearly parallel to the primary lines. Therefore, the structure necks down only slightly when secondary lines take up the load from a damaged primary line and, as a consequence, the structure remains an open net, even in the vicinity of a cut. Thus, a small flying object that could sever a single line in the tether is still unlikely to cause total failure of the tether, even if it strikes in the vicinity of a previous cut.

Numerical simulations and experiments have confirmed the expectation of the inherent ability of these tethers to redistribute loads around severed primary lines and to maintain spacing between primary lines without need for rigid braces. The simulations and experiments have shown that these multiline tethers can withstand multiple cuts while retaining structural integrity and sustaining only mild pinching, which is limited to the vicinities of the cuts. Thus, the lifetimes of these multiline tethers can be orders of magnitude longer than those of single-line tethers with comparable masses.



Secondary Lines Redistribute the Load around a cut in a primary line. The angles of the secondary lines are exaggerated in these views for the sake of clarity; in reality, the secondary lines are more nearly parallel to the primary lines.

This work was done by Robert P. Hoyt and Robert L. Forward of Tethers Unlimited, Inc., for **Marshall Space Flight Center.** *For further information, please contact the company via e-mail at TU@tethers.com or visit their web site at http://www.tethers.com.*

Hoytether™ is a trademark of Tether Unlimited, Inc., for their interconnected multiline space tether design. MFS-31305

Program Simulates Flights of Advanced Aerospace Vehicles

This modular software can be modified for analyzing different vehicles.

Marshall Space Flight Center, Alabama

Marshall Aerospace Vehicle Representation in C (MAVERIC) is a C-language computer program developed for use in performing high-fidelity simulations of flights and analyses of the guidance and control performances of the X-33 aerospace vehicle and the VentureStar reusable launch vehicle (RLV). A secondary purpose served by MAVERIC is determining indicators of vehicle parameters on realistic flight trajectories.

MAVERIC is in a state of continuing development. It is modular and is designed to be readily modifiable for simulating flights of other conceptual advanced aerospace vehicles; indeed, it has already been modified for use in simulating the flight of an orbital transfer vehicle.

The C computing language was chosen for MAVERIC because the X-33 flight software will be in C. Previous available programs that could have been chosen for the present applications were written in Fortran. These programs were not modular and not easily modifiable for high-fidelity computational modeling of the flight of the X-33.

MAVERIC includes subsystem models for the X-33 and the RLV, plus algorithms for monitoring guidance and control performance and trajectory-reshaping algorithms used to fly X-33 and RLV. A MAVERIC simulation can be started at a point other than liftoff. A simulation can include for all phases of flight from launch to the terminal-area energy-management interface [the interface between (1) re-entry into the atmosphere and (2) gliding flight through the atmosphere toward a landing point].

MAVERIC provides options for mathematical modeling of effects of winds, atmospheres, and dispersion. The Global Reference Atmosphere Model and range reference atmospheres are included. A Monte Carlo capability is provided for use in modeling dispersion. Dispersions that can be modeled include those of atmospheres, winds, propulsion, navigation, aerodynamics, and mass properties. Engine-out termination of flight can also be modeled.

MAVERIC is based on the Tframes modular software developed for the U.S. Army for use in simulating vehicles. Detailed descriptions and documentation for MAVERIC do not yet exist.

This work was done by James McCarter, Don Krupp, and Travis Dawson of **Marshall Space Flight Center.** *For further information, contact Larry Gagliano, MSFC Software Release Authority, at (256) 544-7175 or larry.gagliano@msfc.nasa.gov. MFS-31338*

Bio-Medical

Determining Glucose Levels From NIR Raman Spectra of Eyes

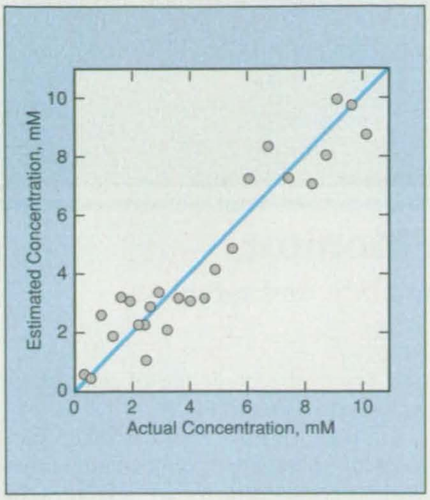
Spectra are processed by principal-component analysis, then artificial neural networks to obtain Bayesian probabilities.

NASA's Jet Propulsion Laboratory, Pasadena, California

A developmental noninvasive method of determining the concentration of glucose in blood is based on (1) the acquisition of a near-infrared (NIR) Raman spectrum from the aqueous humor of an eye, (2) analyzing the spectrum by a combination of techniques described below, and (3) recognition that the glucose level in the aqueous humor of the eye is about 80 percent of that in the blood 30 minutes before the spectrum was acquired. More specifically, what the analysis yields is a probabilistic indication that the glucose concentration represented by the Raman spectrum lies in one of three ranges of physiological interest; hypoglycemic (<3.9 mM), normal (3.9 to 5.8 mM), or hyperglycemic (>5.8 mM). The method involves less NIR laser power and shorter data-collection times than have been used in previous efforts to use Raman scattering to measure glucose concentrations in blood.

One reason for choosing the aqueous humor of the eye as the target for Raman spectroscopy is, of course, that the interior of the eye is optically accessible. Another reason is that whole blood contains numerous optically active materials, the spectra of which obscure the spectral signature of glucose. In comparison with whole blood, the aqueous humor of the eye contains many fewer Raman-active substances to complicate the overall Raman spectrum and the interpretation thereof.

The Raman-active substances in the aqueous humor of the eye are glucose, ascorbate, lactate, urea, and small amounts of protein. The Raman spectrum (absorbance vs. wavelength) of each of these is affected by interactions with all of the other substances present in the aqueous medium, resulting in both linear and nonlinear



Concentrations of 24 Glucose Solutions as estimated from Raman spectra by the method described in the text agreed fairly well with the actual concentrations. In this case, the concentrations estimated by a neural network correspond to a nonlinear least-squares fit to the actual concentrations, with a regression coefficient of 0.955.

variations in Raman spectra with concentrations. Thus, even though only four or five Raman-active constituents are present in significant concentrations, it is necessary to use both linear and nonlinear multifactor analytical techniques to obtain accurate estimates of glucose concentrations from the total Raman spectrum.

In the present method, sets of measured total Raman spectra are first subjected to the classical multivariate-analysis technique known as principal-component analysis. This technique yields a reconstruction of input spectra as linear combinations of feature vectors (eigenvectors of a covariance matrix) that account for the maximum variance in the input spectra. This reconstruction is optimum in the least-squares sense and involves the fewest parameters.

Each feature vector is fed as input to an artificial neural network that is configured to generate either one output or three outputs indicative of the corresponding glucose concentration. Prior to use in this way, the neural network must be trained by use of feature vectors representing known concentrations. Thereafter, if the neural network is configured for one output, then when it is presented with a feature vector from an unknown concentration, the output signal level should represent an estimate of the concentration; alternatively, if the neural network is configured for three outputs, then the signal level at each output terminal should represent a Bayesian *a posteriori* probability that the glucose concentration lies in one of the three ranges of physiological interest.

In vitro experiments on aqueous solutions of glucose at concentrations from 1.01 to 10.1 mM have demonstrated the feasibility of the method. In these experiments, specimens were illuminated with 100 mW of power at a wavelength of 785 nm from a cavity-stabilized laser diode. The Raman spectrum excited by this illumination was measured by use of a holographic imaging spectrographic probe head containing a liquid-nitrogen-cooled charge-coupled device (CCD). The output of the CCD was digitized and processed as described above, using commercial data-acquisition, multifactor-analysis, and neural-network software. The figure depicts some results obtained with a single-output neural network.

This work was done by Michael Storrie-Lombardi, James Lambert, and Mark Borchert of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP) free on-line at www.nasatech.com under the Bio-Medical category.*

NPO-20414

Improved Electrical-Impedance Body-Fluids Monitor

Measurements that yield a variety of data can be done quickly, frequently, and safely.

Lyndon B. Johnson Space Center, Houston, Texas

The Johnson Space Center (JSC) body-fluids monitor advances the state of the art of measuring hydration levels in humans during spaceflight. Neither bulky nor heavy, this noninvasive instrument is built around a commercial inductance-capacitance-resistance meter, which is used to obtain electrical-impedance-vs.-frequency data for equivalent-circuit/electrical-components analyses. The instrument is expected to prove invaluable not only in space-flight settings but also in such other settings as veterans' hospitals, clinical facilities, and medical research laboratories.

The nearest commercial competitor is an instrument, based on a resistance-capacitance meter, that is used to perform bioelectrical response spectroscopy (BERS) for determining hydration levels. Going beyond the commercial instrument, the JSC body-fluids monitor also rates cerebral and other regional blood flows and cardiac outputs by use of time-based assessments of resistance and/or inductance, noninvasively gauges blood pressure by use of resistance and inductance alone, and estimates the lean and muscle mass of a subject's upper and lower limbs in terms of the values of resistors, capacitors, and/or inductors of equivalent circuits derived from electrical-impedance measurements of the human body. A major feature that distinguishes the JSC body-fluids monitor from the commercial instrument is the capability to obtain and utilize data on inductances in addition to resistances and capacitances. Moreover, unlike the commercial instrument, the JSC body-fluids monitor can discriminate between vascular and extravascular water.

Some other methods of measuring hydration levels involve the dilution of tracer substances in the subject's body: In the total-body-water (TBW) method, one uses deuterium-labeled water; in the extracellular-fluid-volume (ECF) method, sodium bromide; and the plasma-volume (PV) method, radioactive iodine attached to albumin. In another method, total body volume is calculated from hematocrit and PV, and bioelectric-impedance analysis (BIA) [which involves measurement of impedance at a single frequency] is used to estimate TBW and ECF. Many of these methods are invasive, and most are time-consuming (a typical measurement takes between 1 and 6 hours), and cannot be repeated until the diluted tracer substances leave the body. These methods also cannot provide information during on-orbit operations. Worse, BIA produces measurement errors greater than those of dilution techniques. Moreover, the performance of the resistance-capacitance-meter-based BERS commercial instrument mentioned above has been challenged because its design makes no provision for modeling inductances; this is critical because inductors are key to the modeling of total blood volume (TBV) and PV.

In 1928, K. Cole originated the concept of using alternating-current measurements to characterize dielectrics dispersed in a conducting medium. In 1941 K. Cole and R. Cole refined this concept into the Cole-Cole principle, which has been applied to biological problems since the early 1960s. For the purpose of Cole-Cole analysis, the human body is treated as both a cylinder and an insulator (cell membranes) surrounding small conductors (the intracellular fluid) embedded in a larger conductor (extracellular water).

Therefore, the human body is treated as a parallel circuit, one limb of which is a purely resistive element that represents extracellular fluid. The other limb, representative of the intracellular component, consists of a resistance and capacitance in series. The commercial instrument mentioned above, operating over the frequency spectrum from 5 Hz to 1 MHz, generates BERS data that are used to compute the resistances and the capacitance.

The JSC body-fluids monitor operates over the frequency spectrum from 5 to 300 kHz. It functions similarly to the commercial instrument except that, as noted above, its design and method of operation account for inductance in addition to resistance and capacitance. More specifically, an inductor is added to the resistance limb; thus, the equivalent-circuit model used to analyze the BERS data is one limb (consisting of a resistor in series with a capacitor) in parallel with another limb (consisting of a resistor in series with an inductor). The inductor represents the inductance of the blood vasculature.

The JSC body-fluids monitor differentiates between vascular and extravascular water even as it noninvasively provides data for an assessment of a subject's TBW, ECF, TBV, PV, and changes in TBV and PV (ΔTBV and ΔPV). These assessments can be performed quickly and safely, and can be repeated frequently. The JSC body-fluids monitor could also be used to estimate

the percentage of body fat, given the assumption that the lean tissues of the body are normally hydrated.

For operation of the JSC body-fluids monitor, a subject is instrumented with four standard electrocardiogram electrodes. Two electrodes are placed on the hand (wrist and knuckles), and two are placed on the foot (ankle and base of toes). A small electric current (below the human ability to feel) is introduced, and the magnitude and phase angle of impedance are recorded as the frequency is varied from 5 to 300 kHz. Electrical-component analysis of the measurement data produces three values of resistance (representing TBW, ECF, and intercellular water content), self and mutual inductance, and capacitance. These electrical-component values, along with the height and weight of the subject, are inserted in computational models developed to assess TBW, ECF, TBV, PV, ΔTBV, and ΔPV. Thus, the JSC body-fluids monitor and the associated data-analysis method yield a greater assortment of data than does any similar instrument/method combination heretofore used to measure a subject's hydration levels.

This work was done by Steven F. Siconolfi of **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Test and Measurement category.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-22491.

Software for Testing Access List Integrity

John F. Kennedy Space Center, Florida

Many networks rely on firewalls or filtering routers for frontline network security. Packet filtering firewalls or routers filter incoming or outgoing packets based on a set of access rules. The IP (Internet Protocol) Packet Generator computer program assists in verifying that a packet filtering firewall is configured correctly, by detecting security holes in the firewall's filtering rules.The IP Packet Generator enables the user to build TCP/IP (Transmission Control Protocol/Internet Protocol) packets and transmit them via the network, to detect errors in access list configuration.The user can specify the source IP address of a packet to simulate attempted access from a remote host. The user can also specify the destination IP address, the type of packet, the destination port number, the size of the packet, the number of packets to send, and the packet rate. Thus, the software helps the user perform an exhaustive test of the access list.

This work was done by Becky Johnson, Mark T. Page, and Henry W. Yu formerly of I-NET for **Kennedy Space Center**.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Technology Programs and Commercialization Office, Kennedy Space Center, (407) 867-6373. Refer to KSC-11878.

Program for Parallel Distributed Processing

This software package automatically distributes mutually independent tasks to networked workstations.

Lyndon B. Johnson Space Center, Houston, Texas

A software system has been devised to manage automatically (1) the distribution of mutually independent computing tasks to computer workstations in NASA's Flight Design and Analysis System (FADS) network and (2) the execution of those tasks on those workstations. This program parallelizes serial tasks, making it possible to execute them concurrently. This program is a substantial improvement over previously developed special-purpose parallel-processing software systems used by NASA.

Parallel execution of tasks takes less time than traditional serial execution does. In the original FADS application, in which the tasks are principally simulations of spacecraft trajectories, this program significantly decreases the run time for simulating spacecraft missions. In a representative case of simulating 6 trajectories in the FADS, this software system can reduce the run time by 80 percent below the serial-processing run time.

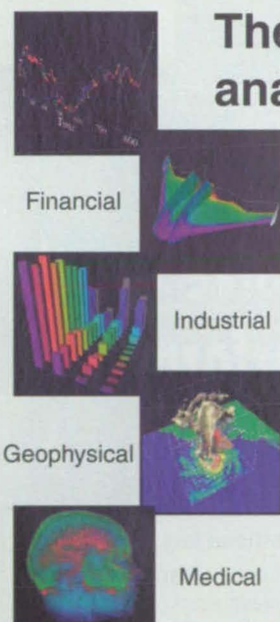
This program can be modified to run on industry-standard workstation networks and is enhanced to handle many modes of operation. As workstation networks increasingly supplant large central computers, this program could become useful in increasing numbers of industrial applications.

Previously developed parallel-processing software concentrates primarily on how busy the computing resources (in this case, workstations) are when queried. The present software limits the distribution of tasks to workstations that are deemed to be idle in the sense that no users are logged into them and they are not executing other distributed work. This approach makes it possible for both distributed execution of tasks and logged-in users to coexist on the network platform without adversely affecting the users' performance.

This program includes three components: a Unix daemon program, a task-distribution executive, and a workstation executive. The daemon is a background program that is started during initialization of operation of each workstation in the network and is used by the distribution executive to determine the state (idle or busy) of each such workstation. The distribution executive reads a list of tasks to distribute, finds operational, idle workstations on the network, and uses the workstation executive to manage the execution of tasks on the available workstations. The distribution executive, keeping track of the status of each task, monitors the network for messages from the workstation executive. The workstation executive starts a task on an idle workstation and monitors both the task and the workstation. When a user logs into the workstation from its keyboard, the workstation executive removes the task from that workstation and notifies the distribution executive to resubmit the task to another idle workstation. When a task is completed, the workstation executive informs the distribution executive.

To maximize adaptability, simplify the development of algorithms, and reduce the cost of maintenance, the distribution and workstation-executive subprograms are written in Practical Extraction and Reporting Language (PERL), which is a very-high-level language (VHLL). In the original FADS application, this program works with the previously developed trajectory-simulating software, without need for any special modifications. However, for other applications, modifications can be made to make this program compatible with industry-standard workstation networks.

This work was done by Mark C. Allman of Rockwell Space Operations Company for **Johnson Space Center.**
MSC-22689



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Subpixel Map Registration and Estimation of Uncertainty

A normal distribution is fitted to the peak of a likelihood function in a pose space.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method of determining the location and the uncertainty in the location of a mobile robot to subpixel resolution on a map grid has been devised. The method is applicable to a robot equipped with stereoscopic vision equipment for mapping the local terrain and with sensors for determining its orientation. The method involves fitting a parameterized surface (usually a normal distribution) to the peak of a likelihood function in the space of possible positions.

This method is built upon the method described in "Localization by Maximum-Likelihood Matching of Range Maps" (NPO-20392) *NASA Tech Briefs*, Vol. 22, No. 10 (October 1998), page 86. The localization problem is formulated as one of seeking a maximum-likelihood match of two maps: (1) a local range map generated by processing of images of the terrain in the immediate vicinity acquired by stereoscopic video cameras mounted on the platform and (2) a previously generated map of a larger surrounding terrain area (a "global" map). The global map could have been generated either by use of panoramic imagery from the robot or by combining the information from previously generated local maps. The points on the local range map are binned in a three-dimensional occupancy-grid representation of the surroundings, at a known orientation with respect to the global-map coordinates. In a subprocess that amounts to high-pass filtering of vertical-position data, the local average of the heights in each bin is subtracted from each cell. This subprocess reduces the computation time needed for localization by eliminating the need to search over vertical translations; in other words, as a result of this subprocess, it suffices to search over horizontal coordinates only.

The degree of matching between the global map and the local occupancy map is quantified by use of a likelihood function defined by the equation

$$L(X)=\prod_{i=1}^{n} p\left(D_i^x\right)$$

where D_i is the distance from the ith occupied cell in the local map to the closest occupied cell in the global map, X is the trial position of the robot (expressed as the trial position of the local map) relative to the global map, $p(D_i^X)$ is a probability distribution function (PDF), and n is the number of occupied cells. The most likely position of the local map relative to the global map [that is, the position, X, that maximizes $L(X)$] is taken to be the position of the robot. The search for this position is started on a relatively coarse grid, from a position that has been estimated, for example, by deductive reckoning. The estimate of position is then refined in a subprocess that involves recursive division of the search space into smaller cells and pruning of cells that cannot pass the maximum-likelihood test.

As described thus far, this method is nearly identical to the method described in the noted prior article. The distinct aspect of this method lies in the provision for both subpixel localization and characterization of uncertainty in the localization. Inasmuch as the likelihood function expresses the probability that each position in the pose space (the space of possible positions) is the actual robot position, the uncertainty in the localization is quantified by the magnitude of the decrease of the likelihood function with distance from the peak. Subpixel localization in the discretized pose space can be performed by fitting a parameterized surface to the peak that occurs at the most likely robot position.

For the purpose of this fitting, it is assumed that in the vicinity of its peak, the likelihood function can be approximated and parameterized as a normal distribution. The fitting then yields both the subpixel estimate of position (namely, the center of the normal distribution) and an estimate of uncertainty (namely, the standard deviation of the normal distribution) centered at the nominal peak location.

The uncertainty is further characterized by a probability that a qualitative failure has occurred. Such a failure could occur, for example, in an environment in which recognizable landmarks are sparse and consequently many locations appear very similar to the robot. The probability of qualitative failure is estimated by comparing the likelihood scores under the tallest peak with the likelihood scores in the rest of the pose space.

This work was done by Clark F. Olson of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Information Sciences category.*
NPO-20657

Books & Reports

Spacecraft Solar-Wind Trim Panels for Pointing

A report proposes that spacecraft assigned to orbits distant from the Earth be equipped with trim panels that would intercept the solar wind to generate small torques to correct for disturbance torques and thereby help to maintain the spacecraft pointed in the required directions. Paired panels would be placed on the ends of opposing moment arms equidistant from the center of mass of a spacecraft. The angles of the panels would be adjusted by use of servoactuators to control the solar-wind forces on the panels and thereby control the solar-wind-generated torques.

This work was done by Richard K. Barry, Jr., of **Goddard Space Flight Center.** *To obtain a copy of the report, "Spacecraft Solar Wind Trim Panels for Pointing and Disturbance Torque Abatement" access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category.*
GSC-14247

Reaction-Forming Method for Joining SiC-Based Parts

Two reports present additional details about the method described in "Reaction-Forming Method for Joining SiC-Based Ceramic Parts" (LEW-16661), *NASA Tech Briefs*, Vol. 23, No. 3 (March 1999), page 50. To recapitulate: A carbonaceous mixture (typically a paste) is applied to a joint between parts. The parts are clamped together and heated to a temperature of 115±5 °C for 10 to 20 minutes; this action partly cures the mixture, gluing the parts together with just enough strength that one need not clamp the parts during subsequent processing. Silicon or a silicon alloy in tape, paste, or slurry form is applied to the joint region. The parts are heated to a temperature between 1,250 and 1,425 °C for 5 to 10 minutes, causing the silicon or silicon alloy to melt, infiltrate the joint, and react with carbon. The finished joint, which is typically as strong as the parent material, contains silicon carbide with silicon and other phases. The amounts of the phases can be adjusted, by choice of the compositions of the reactants, to obtain joints with tailorable microstructures and thus tailorable thermomechanical properties.

This work was done by Mrityunjay Singh of NYMA, Inc., for **Glenn Research Center.** *To obtain copies of the reports, "A New Approach to Joining of Silicon Carbide-Based Materials for High Temperature Applications" and "Affordable, Robust Ceramic Joining Technology (ARCJoinT)," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16827.

Model-Based Tools for Automotive System Design

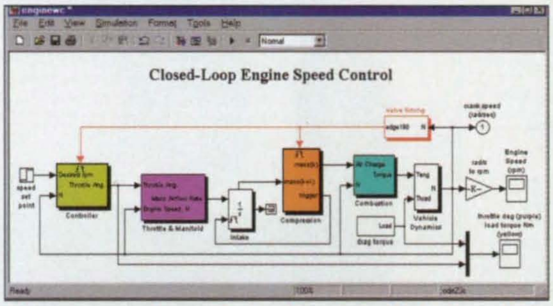
To gain competitive advantage, auto makers are relying on engineers and systems designers, using model-based design tools, to create the systems that satisfy customer demand and meet government requirements.

It is a basic tenet of the automotive industry: With each new model year, automobiles become more complex. Because consumers demand higher quality vehicles that also enhance their driving comfort and enjoyment, auto makers are creating advanced automotive systems that incorporate the latest materials, integrated electronics, environmental considerations, and safety enhancements under extreme time-to-market pressure. To gain competitive advantage, automobile manufacturers rely on their engineers and systems designers — who use model-based design tools — to create the control and electronic systems that satisfy consumer demand and meet government regulations.

In most cases, control and electronic systems such as anti-lock brakes, powertrain controllers, and engine control units, are implemented using embedded systems. Embedded systems are hardware and software built around a central processor or control logic that performs sets of functions or tasks. As these embedded systems become increasingly significant components of the overall makeup of an automobile's systems, designers face added pressure on a number of fronts:

- Creating embedded systems that perform complex, demanding tasks.
- Developing systems that work as specified and are completely reliable in mission-critical applications — a malfunctioning anti-lock braking system is not an option.
- Reducing the cost to develop embedded systems for new products. Today, embedded systems and related electronics can represent as much as 30 percent of the overall cost of designing a new vehicle.
- Accelerating product development cycles. Manufacturers hope to slash in half the time it takes to design and develop new cars.

The design process most commonly used for previous generations of vehicles was not sufficient to meet these demands, particularly when complex systems were involved. Since then, engineers at top automotive manufacturers have changed their design methodology to utilize a paradigm that focuses on modeling an automotive system at a higher level, including the modeling of the vehicle's environment. This model-based design paradigm for embedded systems uses computer-modeling techniques throughout the design process, not just in the research phase, which is the traditional venue for these tools. As a result, engineers achieve significant reductions in design cycles while increasing the quality and performance of the automotive systems.



This engine speed controller model contains blocks for multiple subsystems, including throttle and manifold settings, intake, compression, combustion, and vehicle dynamics. The hierarchy of models is represented in the throttle and manifold portion of the model.

The Embedded System Design Process

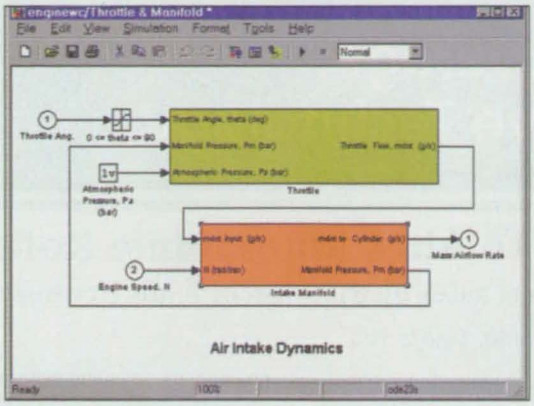
The design process for automotive systems, particularly complex subsystems like closed-loop control systems (such as engine control units), typically consists of multiple phases. In the first phase, a research and development team's conceptual design for a subsystem or component is optimized and moved into the mainstream engineering process flow. Using graphical design and simulation tools, such as MATLAB® and Simulink® from The MathWorks, automotive systems designers build a mathematical model of the subsystem or component from the specification. Then, engineers use a graphical block diagram editor to model the component and its vehicle as one dynamic system. As the initial high-level models are completed, engineers add the necessary hierarchical levels of detail until the desired system is completely implemented within the model of the vehicle's environment.

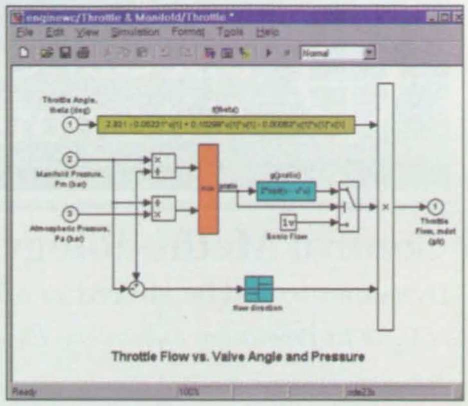
The next steps involve the generation of algorithms that define how the embedded system will run in a real vehicle, based on operating conditions and desired output responses. For example, an engine controller must provide control signals to engine subsystems to maximize performance across a given range of engine speeds, while meeting emissions regulations and fuel economy goals. Vehicle sensor data, desired performance goals, and environmental conditions also need to be integrated to achieve optimal output, and delivered continuously in real time. They also must remain invisible to the driver. The result is a graphical schematic model of a closed-loop control system that can then be simulated, corrected, and refined by manipulating the mathematical algorithms inherent in the design.

Additional steps document the control algorithms, then convert them into software code that can be targeted to a processor that will ship with the vehicle. For large projects, the process may require the work of several engineering groups, beginning with research engineers who develop the engineering solution. Production control engineers and systems engineers then handle the system design and analysis, and software engineers are responsible for coding. Finally, test engineers, systems engineers, and calibrators perform the testing and validation.

In each stage of the design process, a partially completed model can be simulated, verified against the initial performance specifications, and ultimately approved. Returning to the engine controller example, the unit can be evaluated using stored data from previous

vehicle tests as input for the completed model. This data provides simulation flexibility and system optimization without the high costs of creating multiple physical prototypes. In addition, multiple engine models can be utilized to evaluate various options and configurations. In the final stage, the model fully conforms to its original specifications and has been validated throughout the design process via precise simulation.





The left image represents the throttle and manifold model, and the right image is a graphical representation of the model, which determines throttle flow based on angle, manifold pressure, and atmospheric pressure.

This model-based design paradigm is significantly different from the traditional design methodology used in the development of automotive systems. Rather than structuring and writing software code, designers define functional characteristics using continuous-time and discrete-time building blocks. Code is then generated automatically from the diagrams and incorporated on a processor. Modeling and simulation also lead to rapid prototyping, software testing, and verification. Not only is the testing and verification process enhanced, but also in some cases, hardware-in-the-loop simulation can be used with the new design paradigm to develop tests more quickly and efficiently.

Working with advanced software tools, engineers employ real-world data to mathematically model the vehicle and peripheral components where the embedded system is to operate. Modeling creates natural, high-level graphical descriptions such as block diagrams and state diagrams to represent the system, and captures knowledge and implementation details about the system. This approach supports both top-down and bottom-up design and can be used to support the entire design cycle. Engineers develop models for components (the transmission, exhaust system, cooling system, fuel system, and gearbox, for example), then utilize those models in multiple applications and under variable operating conditions. With the engine control unit, the model simulates many vehicle platforms and quickly integrates with various engine models, a practice that is very difficult to implement with real hardware.

Along with creating a model of the vehicle's operational environment, engineers develop a data flow model of the desired control system. This model clearly specifies desired system operations and forms a set of "executable specifications" that can replace or supplement written specifications with a graphical model. The executable specifications become the means of communication for different engineering groups or between automotive manufacturers and automotive component suppliers.

Since a dynamic control system is modeled and simulated, it identifies defects in the design early in the development process, allowing automotive engineers to correct flawed specifications. The changes are captured in successive iterations of the graphical model that provides the executable specification. In later stages of development, the perfected model becomes the foundation for code generation and the automatic generation of test cases. In fact, the executable specification can demonstrate the desired operations of the system to customers, suppliers, and other stakeholders. Its successful simulation assures the interested parties that the design meets usability requirements and is designed correctly.

Consequently, the executable specification also can be used to define and validate software and hardware that is designed separately in the design process, and to accelerate the rapid prototyping process. In the case of the engine controller, rapid prototyping demonstrates that the software code generated for the unit runs correctly in real time when it is connected to a real engine. The code is instrumented to allow for tuning and the calibration of parameters. The results can then be used to refine the model to ensure that it will work properly in the vehicle.

More Reliable Systems

The design process for automotive embedded systems is characterized by a series of phases starting with specification, moving through design to verification, and concluding with system integration and calibration. The model-based design paradigm integrates these multiple phases and provides a common framework for communication throughout the entire design process. The first step is the high-level modeling of the vehicle's operational environment, followed by the modeling, simulation, and prototyping of the embedded system. These stages lead to an executable software specification from which code can be generated automatically and incorporated into an embedded microprocessor. The high-level model also can be used in the verification process, both for rapid prototyping and hardware-in-the-loop system-level testing.

The model-based design methodology promotes faster design iterations, better designs, and enhanced reliability of automotive components and systems. The software tools, hardware capacity, and know-how needed to effectively implement the model-based design paradigm are available, and automotive manufacturers are deploying them. Because it is critical to be able to demonstrate that the simulated environment is an appropriate representation of reality, modeling and simulation tools will continue to improve to provide more accurate representations of automotive systems.

In some cases, collaborations between software vendors and their customers are already leading to significant advances in modeling and simulation techniques. For example, The MathWorks has worked with top automotive companies for a number of years to understand their needs for powertrain control system design tools. This interaction has led to breakthrough solutions for state machine and flow diagramming, simulation, automatic documentation, rapid prototyping, and code generation.

With modeling and simulation software tools being continually enhanced, the model-based design paradigm for embedded systems is becoming increasingly commonplace. Many companies already are finding that it leads to better, more reliable systems that are developed more cost effectively in shorter amounts of time.

This article was written by David Helinek, Automotive Industry Manager, at The MathWorks, Natick, MA. For more information, contact the author at 508-647-7000, or visit www.mathworks.com.

Special Coverage: Automotive Technology

Control Methodology To Alter Automobile Rollover Tendencies

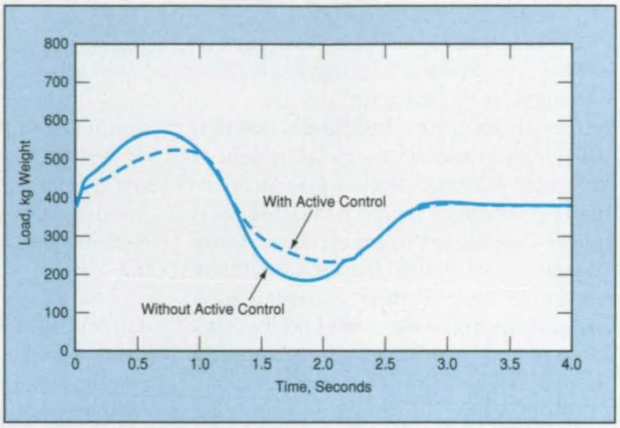
Dynamics would be altered to effect safer distribution of loads to wheels.

NASA's Jet Propulsion Laboratory, Pasadena, California

A methodology of active control has been developed in an effort to alter (preferably to reduce) the tendency of a four-wheel land vehicle to roll over during tight turns and similar maneuvers. At the time of reporting the information for this article, hardware and software to implement the methodology were undergoing development and testing for incorporation into a variable-dynamics testbed vehicle (VDTV) — an experimental automobile that will be capable of exhibiting a broad range of dynamic characteristics for research on crash avoidance and driving-related human factors.

The VDTV will have four-wheel steering, front and rear active antiroll-bar systems, four adjustable dampers, and other active control devices that will be controlled by a computer running algorithms based on mathematical models of the dynamics of the vehicle. These devices will be used to alter several rollover-related characteristics of the dynamics of the vehicle, including notably its understeer coefficient, front/rear load-transfer distribution in lateral maneuvers that involve high accelerations, and the frequency and damping coefficient of the vehicle roll mode. Load-transfer distributions are particularly significant because to prevent rollover, one must ensure that the load on any tire never approaches zero during a severe maneuver.

A study has been performed to investigate how changes in the algorithms that control the active devices could effect significant changes in these characteristics. In particular, the study focused on how (1) an increase in the stiffness of the front antiroll bar, in conjunction with an increase in the front damper rate and with out-of-phase rear steering, could increase resistance to rollover in high-acceleration lateral maneuvers without changing the vehicle understeer coefficient (see figure); and (2) conversely, an increase in the stiffness of the rear antiroll bar, in conjunction with decrease in the rear damper rate and with in-phase rear steering, could decrease resistance to rollover. The results of the study indicate that the design of the VDTV provides for the right combination of active devices that will make the VDTV an effective testbed for research on rollover-related human factors.



The **Load on the Left Rear Tire** of the VDTV was simulated by computer for a two-lane-change maneuver. By use of active control to increase the stiffness of the front antiroll bar, the minimum load at an extreme point of the maneuver was increased, thereby increasing the margin against rollover.

This work was done by Allan Y. Lee of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category.*

NPO-20545

Program for Computing Dynamics of Multiple Bodies

Relative to other programs used previously for the same purpose, computation times are reduced.

Lyndon B. Johnson Space Center, Houston, Texas

Symbolic Generator-Based Efficient Multibody Dynamics Algorithm (SOMBAT) is a program that enables speedy and accurate computations that solve equations of motion of multiple bodies. Originally intended for space-based applications (i.e., solving equations for the dynamics of a cluster of flexible bodies in orbit in real time), SOMBAT can also be applied in designing drugs, enhancing and otherwise processing images, the automotive industry, and robotics. It can also be used by the Department of Defense. Its greatest strength is its ability to reduce computation time without sacrificing accuracy. Unlike programs modeled on n^3 algorithms, SOMBAT accrues time savings overruns while satisfying short-turnaround requirements. Moreover, and vitally for the U.S. Space Program, the open and expandable format of SOMBAT will enable the tailoring of this program to upgrade add-on systems for new International Space Station (ISS) modules.

SOMBAT satisfies the specific need of NASA's International Space Station Program (ISSP) for a software tool to simulate the dynamics of multiple bodies with large articulating angles in orbit. Before the advent of SOMBAT, simulation software tools followed an order-of-n^3 approach. One pre-SOMBAT software tool, TREETOPS (a generic configuration-independent program with an n^3 algorithm) assembles equations of motion for all bodies in a configuration before solving for the dynamics at each time step. Because the size of the mass matrix (which size is an indicator of efficiency of com-

putation) in TREETOPS is equal to the sum of all active degrees of freedom, TREETOPS becomes prohibitively slow when the number of active coordinates increases. Clearly, TREETOPS cannot be used to perform real-time simulations for ISS applications. Once it was determined that the generic nature of such simulation software as TREETOPS was not suited to the ISSP, another solution was sought.

SOMBAT is that solution. SOMBAT uses the ISS configuration to develop a more efficient algorithm that acts as a "smart" program to optimize generated code for the configuration. Savings are realized through two innovations: (1) improved mathematics for solving equations and (2) software that implements the improved mathematics to optimize the simulation and avoid redundant calculations. The first innovation involves an order-of-*n* algorithm capable of exploiting the core-body/branch-body configuration to reduce all equations in terms of core-body degrees of freedom. Inasmuch as the inverted mass matrix generated by this algorithm is much smaller, the algorithm affords a substantial reduction in computation time.

The second innovation is a code-generator software tool — Codegen — that is able to develop a simulation based on active degrees of freedom. It does this by selecting equations of motion for a configuration without generating equations associated with degrees of freedom. Multiplication by zero is eliminated at the code-generation stage and the generated simulation is configuration-specific. As long as the configuration does not change, the same code can be used over and over again — a significant advancement. Codegen also simplifies equations by use of established mathematical relations, dot products, cross products, and linear algebraic relations; and it can take input from the user to optimize generated code. Together, these innovations ensure that SOMBAT achieves efficiencies unmatched by n^3 algorithms.

The major advantage of using SOMBAT is the recurring savings in computation time it delivers. In some ISS tests, SOMBAT was found to be 80 times faster than such older programs as TREETOPS. Although the generated code is configuration-specific (if the configuration changes, the code must be regenerated), this is not a major problem for SOMBAT, because SOMBAT easily regenerates code within minutes. Inasmuch as it accrues a saving of time over each run, SOMBAT is ideally suited to test runs. Moreover, its open and expandable format makes SOMBAT tailorable for future updates to the space-shuttle or Russian control systems on the ISS — systems that may be added to the ISS in the form of new modules. Finally, SOMBAT meets or exceeds industrial standards when it is applied in the other technological disciplines mentioned above. When speed and accuracy are needed to simulate the dynamics of multiple bodies, SOMBAT is faster and more accurate than any other algorithm currently available.

This work was done by Ramen Singh of Dynacs Engineering Company, Inc., for **Johnson Space Center.**
MSC-22782

Ultracapacitors Store Energy in a Hybrid Electric Vehicle

Capacitors are superior to batteries with respect to energy density, longevity, and performance.

John H. Glenn Research Center, Cleveland, Ohio

A government/industry/academic cooperative has developed a hybrid electric transit bus (HETB). The goals of the development program, which continues, include doubling the fuel economy of city transit buses currently in service, and reducing emissions to one-tenth of the levels allowed by Environmental Protection Agency (EPA) standards. A unique aspect of the power system of the HETB is the use of capacitors in its the energy-storage subsystem. At a gross weight of more than 17,000 kg, this is the largest known vehicle to use capacitors to store energy.

Energy storage has always been a problem for electric vehicles, and even a greater problem for hybrid electric vehicles. In a purely electric vehicle, energy is stored, usually in batteries, and then used to power the vehicle until the energy is depleted. At that time energy is stored once more by recharging the batteries. In a hybrid electric vehicle, energy is constantly being stored and used; the repeated charging and discharging puts a tremendous strain on the batteries. This type of use reduces the lifetimes of presently available batteries.

Ultracapacitors that are now available eliminate many of the problems of batteries for hybrid electric vehicles. The ultracapacitors used in the HETB are electrochemical capacitors, which have extremely high volumetric capacitances because of large electrode surface areas and very small electrode separations. The cycle lives of capacitors can be extremely long relative to those of batteries. Thus, it may never be necessary to replace the energy-storage medium in the HETB; consequently, the reliability of the HETB energy system is greater than it would be if batteries were used, the life-of-system cost is reduced, and adverse environmental effects are diminished.

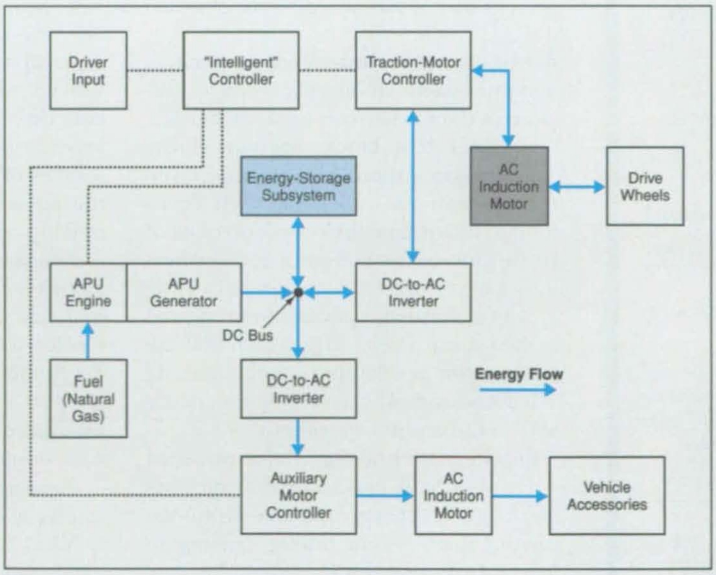


Figure 1. The **HETB Power System** includes a dedicated power-management controller and an energy-storage subsystem that utilizes capacitors instead of batteries.

Capacitors can also function at power densities greater than those of batteries. Therefore, very high power levels can be provided during acceleration and can be absorbed during charging. Capacitors have excellent low-temperature characteristics, do not require maintenance, and provide consistent perfor-

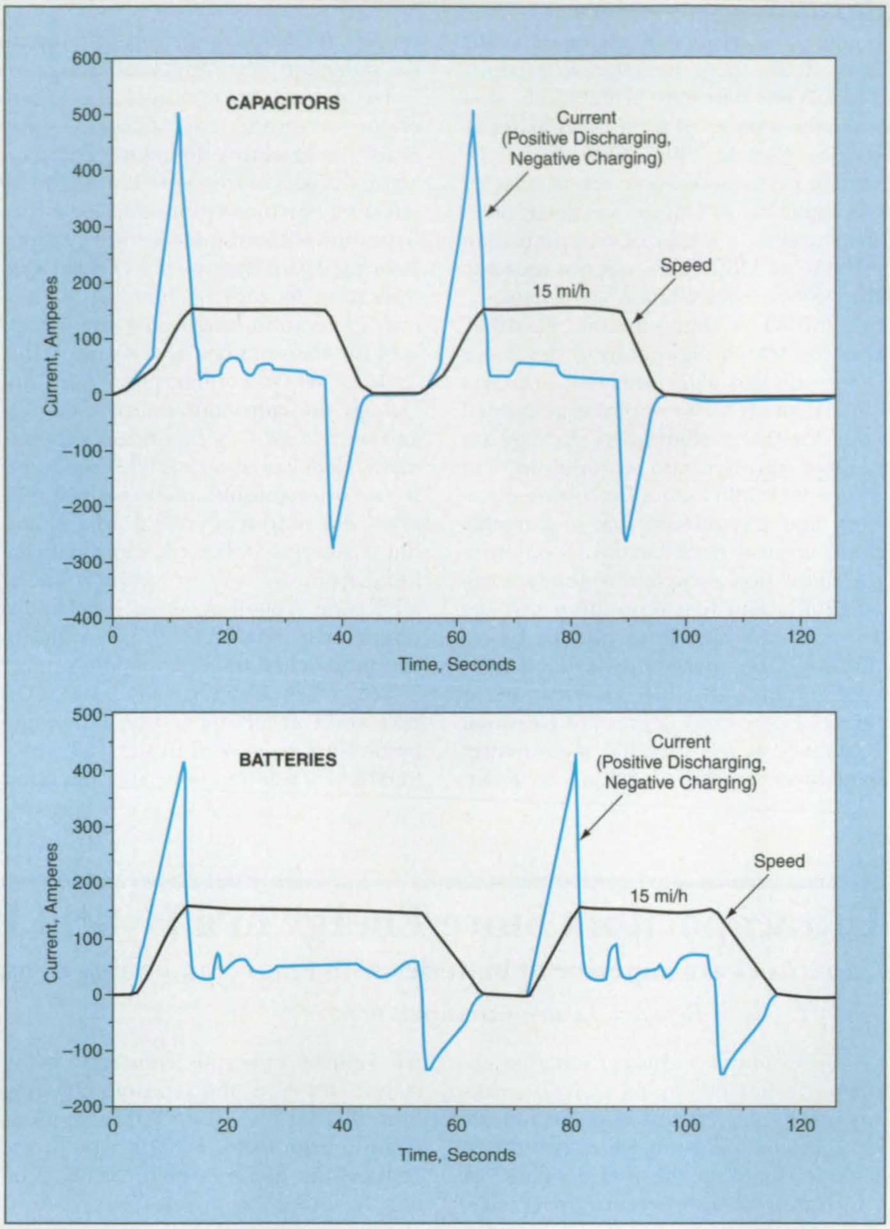


Figure 2. **Charging and Discharging Currents** were measured in two tests, in each of which the HETB was driven through two cycles at speeds between 0 and 15 mi/h (0 and 24 km/h). In one test, capacitors were used to store energy; in the other test, batteries were used.

mance over time. In addition, capacitors promote safety in electric vehicles because of their relative ease of discharge.

Figure 1 is a block diagram of the HETB power system. A dedicated power-management controller has been developed to coordinate the operation of all of the various vehicle components. The auxiliary power unit (APU) is set to provide the normal average power level required by the vehicle. Power surges such as those needed for acceleration and climbing hills are provided by a combination of the APU and the ultracapacitors.

Regenerative braking is also provided on the vehicle. Regenerative braking takes advantage of energy available from the traction drive system during braking to charge the energy-storage system. Because of their higher power-density limits and their greater efficiency in capturing energy, capacitors can take much greater advantage of regenerative braking than do batteries. The plots in Figure 2 show the superiority of capacitors over batteries as sources of current for the traction motor during acceleration and as acceptors of braking current during deceleration.

This work was done by Jeffrey C. Brown, Dennis J. Eichenberg, William K. Thompson, and Larry A. Viterna of **Glenn Research Center** *and Richard F. Soltis of Cortez III. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16876.

April 2000

Motion Control Tech Briefs

Software that Keeps the Grass Green

The Cleveland Browns' stadium turf grows and grows thanks to an advanced piping network designed with the aid of Algor software.

Rising twelve stories above Lake Erie, the state-of-the-art Cleveland Browns stadium boasts some impressive statistics: 72,500 seats, 148 luxury boxes, 103 permanent and portable concession stands, 948 toilets, and 11.65 miles of plumbing pipe. Also at the top of the notable list is a turf conditioning system consisting of more than 40 miles of PEX pipe installed beneath a playing field of natural, fully irrigated turf 75 yards by 115 yards. Designed and installed by Virginia-based Rehau Inc. North America, the turf conditioning system enables healthy green turf to grow long after the normal growing season, which is important to playing year-round outdoor football in Cleveland.

Rehau's turf conditioning system distributes heated fluid from a series of boilers through an underground piping network. The heat radiates through the soil to keep the grass root zone at a constant temperature, preventing the field from freezing even in chilly lake-effect weather. Without the system, the field would deaden late in the football season, resulting in severe damage, since the turf would be unable to repair itself after the wear and tear of a Sunday afternoon game.

Rehau engineers used heat transfer analysis software from Pittsburgh-based Algor Inc. to determine the amount of energy required to run the system and optimize overall system performance under varying environmental conditions. In addition, replays of Algor's transient heat transfer analysis results provided stadium developers with a visualization of how the existing turf conditioning technology would work at the new stadium.

The new Cleveland Browns stadium, the site of an advanced turf conditioning system designed with Algor software, with the piping network exposed on its bed of gravel.

Drawing on Proven Technology

While Algor was new to the design of the conditioning system, the technology used to build the system was tried and tested for more than 25 years, according to product manager Patrick Sauer.

"The Cleveland turf conditioning system uses Raupex™ piping, which is made of high-density cross-linked polyethylene," Sauer explained. "Individual polyethylene molecular chains are linked into a 3D network under high temperature and pressure to provide superior strength and flexibility." Rehau's cross-linking process, developed by German scientist Thomas Engel and licensed by Rehau in 1967, significantly enhances the temperature resistance, long-term strength, impact strength, creep resistance, and elastic behavior of the polyethylene. The Cleveland turf conditioning system is a closed-circuit system that uses Raupex piping with a 3/4-inch diameter arranged in rows beneath the surface of the playing field, end zones, and sidelines. The piping segments are connected at approximately 2000 circuit

locations using Rehau's patented Everloc™ fitting system. As fluid circulates from the boilers, it flows through several large headers, which then branch off into smaller circuits to uniformly heat about 96,000 square feet of surface area. The system is divided into four rectangular sections that can be independently controlled so that if part of the field is shaded, for example, it can be heated without overheating the other areas of the field.

System designers used Algor's steady-state heat transfer analysis software to optimize the piping spacing to insure uniform heating. If pipes are placed too far apart, brown strips of grass may appear on the field's surface where the grass root zone is not heated adequately.

The flow of fluid through Raupex pipe causes it to expand. Its molecular structure enables it to compress to its original shape after expansion, but this causes significant loading on fittings that connect individual piping segments. According to Sauer, the Everloc fitting system takes advantage of the pipe's compressive properties.

"The pipe is expanded over an Everloc insert to provide maximum strength, without reducing the inside diameter of the pipe," Sauer said. "Then a sleeve is pressed into the fitting to insure the integrity of the connection. This fitting system enabled us to design the conditioning system without worrying about the accessibility of the joints after installation."


Workers install cross-linked polyethylene pipe, more than 40 miles of it, through which fluid flows to heat the turf's root zone.

The pipe network lies on a bed of gravel beneath a sandy soil mixture. The composition and moisture level of the soil can affect the conductivity of heat from the pipes through the soil to the root zone inches above. Sandy loam releases fluid at a faster rate than dense clay soil, while wet soil releases more energy in the form of heat into the air than dry soil does, causing faster decreases in field temperature. On the other hand, drier soil releases less heat from the field, but requires longer periods of time to heat the root zone.

According to Sauer, the herringbone construction of the gravel drainage system beneath the pipe network helps to prevent downward heat loss, optimizing the amount of heat that reaches the root zone above. Rehau engineers also needed to consider external variables, including weather conditions and the length of the grass, in the Algor heat transfer analyses. The wind speed, which helps to determine the heat transfer coefficient in the analysis calculations, and the ambient temperature will affect the rate of heat loss from the surface. In addition, longer grass will retain more energy than will shorter grass. According to project analyst Scott Posey, these varying factors required new considerations when performing the heat transfer analysis.

"This application was different from other heat transfer analyses I've performed. In this case, the heat is transferred to another substance entirely, not just across a uniform surface having one material type," Posey said. "The heat transfer analyses also helped us to better understand how external environmental conditions can affect thermal conductivity." Based on the steady-state results, Posey also developed transient heat-transfer analyses to determine how the system would respond to changes in external environmental conditions over time.

Tracking the Variables

To be awarded the Cleveland turf conditioning system contract, Rehau needed to demonstrate both installation and operational costs, including the quantities of pipe needed, energy required to operate the system (which determines the number of boilers needed) and the temperature at which a tarp would be required to protect the field. The required fluid temperature within the system was the key to determining all of these factors.

Posey started with a steady-state heat transfer analysis to find the optimal fluid temperature needed to keep the root zone at 72 °F when the ambient temperature is 5 °F, the criteria specified by the stadium developers. He created a 2D isotropic model of a typical cross section, which consisted of two parallel pipes within layers of gravel, soil, and turf, using Superdraw III, Algor's single user interface for FEA and precision finite element model-building tool. Posey used hand-meshing techniques to make a uniform mesh across the model and then refined the mesh around the pipes. Once he had built the model, Posey used individual groups with representative colors (i.e., group 8, identified as gray, was used for gravel) to specify the different material properties for gravel, turf, soil, and polyethylene. The 1993 Ashrae Fundamentals Handbook provided material properties for gravel and turf, including convection coefficients for turf under varying wind speeds and at no wind speed, which Posey used in this case. In addition, Posey used the Ashrae handbook to find the appropriate material properties for the soil.

"We consulted with the field contractor to determine the approximate soil composition and moisture level to use in the analysis and then sourced the handbook to get the properties," Posey said. "We assumed a conservative moisture level of 42 percent to insure the system would be effective through highly conductive soil."

The material properties for polyethylene were taken from Rehau's past extensive materials research and testing. Using Algor's Material Library Manager, Posey added the material properties to a customized library so that they will be available for future analyses.

Finally, Posey added a temperature boundary of 58 °F, the ground temperature at that depth, to the bottom edge of the model and a temperature boundary of 128 °F at the internal circumference of the pipes. According to Posey, he chose a temperature of 128 °F based on Sauer's extensive design experience with previous conditioning piping systems. In addition, the maximum allowable temperature for Raupex piping is 140 °F.

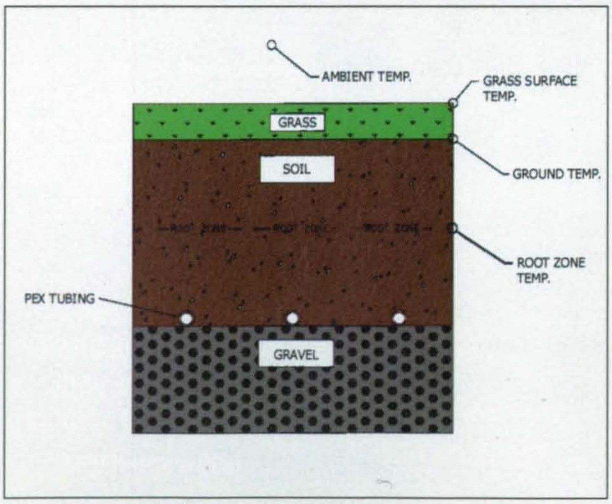
With Sauer's knowledge of such systems as a guide, Posey conducted about five analysis iterations, in which he varied the fluid temperature and pipe spacing, to verify the optimal conditions to properly heat the field surface area. Posey found Algor's total flow option, which automatically calculates heat flow over a surface, to be especially useful in determining the conditioning system's heating requirements. "In the past I have manually calculated the total heat flow by averaging heat flux values at individual nodes. This is a linear approach to an often nonlinear problem," Posey said. "With the total flow calculation, the software saves me time by automatically calculating these values, and it provides a more accurate result."

Posey examined the temperature distribution and heat flux resulting, using Algor's built-in visualization capabilities, and determined that a fluid temperature of 128 °F would sustain the minimum root zone temperature. Factoring in this temperature value, Sauer and Posey calculated the energy required to operate the system in BTUs per hour per square foot. The calculation indicated that the Cleveland turf conditioning system would require a maximum of nine boilers under severe conditions; however, the engineers estimated that just half that number would be needed under normal conditions.

When the Thermometer Drops

The need to regulate the number of boilers in use and to adjust the fluid temperature to accommodate environmental changes led Posey to explore how quickly the system could respond to falling air temperatures. He was able to do this using Algor's transient heat transfer analysis software.

Using the same model geometry and material properties, Posey set up the transient heat transfer analysis to simulate a drop in ambient temperature similar to what would occur over the course of a sunset, and a corresponding rise in fluid temperature to keep the root zone at a constant 72 °F. He adjusted the temperature boundary conditions, defined load curves, and specified the duration of the event for the transient analysis.



The pipe network lies on a bed of gravel, as shown in this cross section.

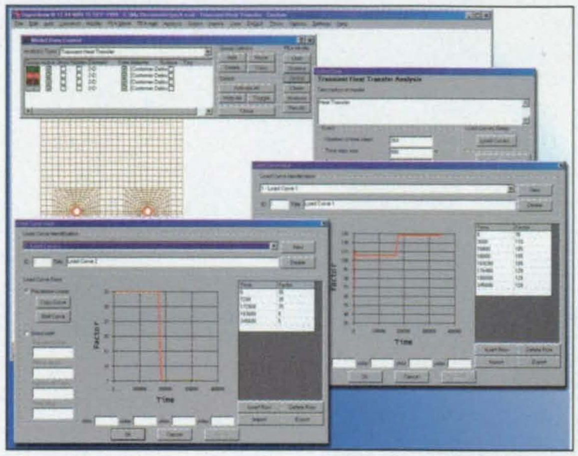
Posey first ran a steady-state heat transfer analysis to determine the fluid temperature needed (105 °F) to maintain the root zone temperature with an ambient temperature of 35 °F. Then for the transient heat transfer analysis, he set the duration of the event. Posey specified 384 time steps (for every 15 minutes for four days) and then defined a capture rate of one, so that he could review the results for each time step. Posey also redefined the applied temperature boundaries at the inside pipe circumference to correspond with the first load curve, which described changes in the system fluid temperature. Then he placed temperature boundaries at the top of the model (at the turf surface) to correspond with the second load curve, which described the changes in ambient temperature.

The first load curve caused the system fluid temperature to ramp up to the previously analyzed temperature of 105 °F and then establish a steady-state situation. Then Posey increased the temperature again to 128 °F to correspond with the second load curve, which simulates a drop in ambient temperature from 35 °F to 5 °F over a period of about three hours. Posey ran several analysis iterations to determine when and how much to increase the fluid temperature as the ambient temperature drops.

"The load curve plots displayed in Superdraw's data entry screens let me visualize load curve data and ensure that it was correct before running the analysis," Posey said. "Conducting the transient analyses required a lot of trial and error on my part," continued Posey, who had had no prior experience with this analysis type. "I was able to successfully perform the analyses with the help of the documentation provided through Algor's DocuTech system."

The Rehau engineers used Algor's Monitor utility to superimpose temperature changes vs. time plots for the fluid, soil, root zone, and turf. Having all of the data on one screen, Posey was able to conclude that the system fluid temperature should be increased slightly before the anticipated drop in ambient temperature to keep the root zone temperature constant. Posey also generated analysis replays in AVI format to animate the changes in temperature distribution over time.

"Algor's bitmap-to-AVI converter enabled me to add in text at important points throughout the event. This helped to explain what happens in the analysis to others who may not be familiar with our turf conditioning system or finite element analysis," Posey said.



Algor's transient heat transfer analysis software was used to simulate a method of keeping the turf's root zone at a constant temperature.

Algor's transient heat transfer analysis software illustrated system performance under falling environmental temperatures, showing that the system is capable of adjusting to changing conditions without dramatic temperature changes at the root zone. The transient heat transfer analysis also verified the performance capabilities for an automatically controlled heating system. In addition, replays of the transient results provided an invaluable visual tool that aided Rehau in earning the Cleveland turf conditioning system contract, according to Sauer.

"While the technology used in the Cleveland system is not new for Rehau, the use of Algor heat transfer analysis software was new," Sauer said. "Being able to illustrate how the system works using analysis replays was an important factor in the contract discussions for the Cleveland project. The analysis replays also have been an integral part in securing additional contracts with other NFL stadiums."

Rehau is already planning future transient heat analyses using Algor software. The engineers plan to study how the turf conditioning systems can be used as cooling mechanisms to keep turf from scorching during the humid summer months or in year-round hot climates. Rehau is currently developing turf conditioning systems for other NFL teams.

For more information, contact Julie Halapchuk at Algor, Inc., 150 Beta Drive, Pittsburgh, PA 15238; (412) 967-2700; e-mail: jhalapch@algor.com; fax: (412) 967-2781; www.algor.com.

Neural Networks Monitor the Health of Space Shuttle Valve

Passive system learns nuances of a valve and evaluates performance in real time.

Oklahoma State University, Stillwater, Oklahoma

The gaseous hydrogen flow control vale (GH2FCV; see Figure 1) is a critical space shuttle component that controls the pressure of the hydrogen external tank during launch and ascent to orbit. The valve is one of the components that are to be monitored by the Integrated Vehicle Health Monitoring (IVHM) system. The GH2FCV is a two-position valve that is actuated by electromagnetic force acting against a return spring. In the de-energized position, the gaseous hydrogen flow is high; when the valve is energized, flow is reduced. There are three such valves on the shuttle, one connected to each of the three main engines and manifolded together to return hydrogen gas to the external tank (see Figure 2).

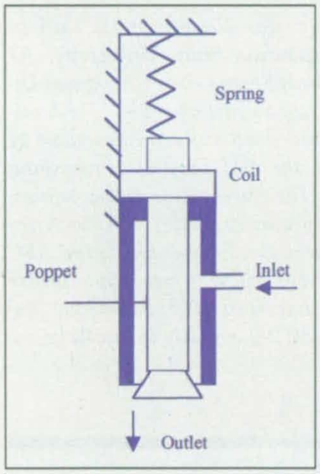


Figure 1. **Gaseous hydrogen flow control valve (GH2FCV).**

The valves are precision manufactured but, in spite of this, each exhibits slightly different operating characteristics from the others. Each valve is routinely tested prior to flight and upon return, but cannot at present be tested during flight.

Testing is performed by actuating the valve, recording the data, and having experts evaluate the current signature. The latter is the current-vs.-time waveform exhibited by the valve as it is energized and de-energized (Figure 3). The characteristic waveform is similar for all GH2FCVs, but small tolerance changes in manufacture and other variables make each valve unique and the corresponding waveforms different. The exact curve signature is a function of electrical and mechanical characteristics of the valve as well as many other variables. It is precisely these subtle changes in the curve signature that yield information about the status of the valve. Thus knowledge of the specific valve and its history are needed to make a good assessment.

This fact makes it necessary to have experts interpret and evaluate the waveforms. If any anomalies are detected, or even suspected, the valve is replaced for safety reasons. Testing, therefore, is subjective, expensive, and time-consuming. Automating this procedure, especially having the ability to monitor the valve in flight, would reduce maintenance time, extend the operating life of the valve, and improve knowledge of the valve's overall health.

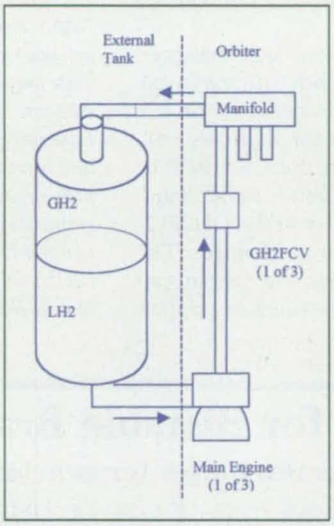


Figure 2. **Location of GH2FCV.**

To address this problem, Oklahoma State University utilized neural networks (NN) trained to recognize the unique characteristics of the individual valve and its fault conditions. Once properly trained, the NN automatically evaluates and reports on the health of the valve each time it is operated. A prototype system was designed and built by Oklahoma State University and demonstrated to NASA personnel. The prototype consists of a personal computer (PC), a smart box, and a current sensor (see Figure 4). The current sensor signal is amplified and digitized. The data is collected, with 8-bit resolution at 10,000 samples per second. When the valve is energized or de-energized, the waveform is analyzed and the results of the particular activation are displayed on a 2-line by 16-character display that is an integral part of the smart box. The PC is used only for user interface and initial NN design and training. Once training is complete, the smart box operates standalone and may be disconnected from the PC.

To operate the system the user is prompted by a graphical user interface

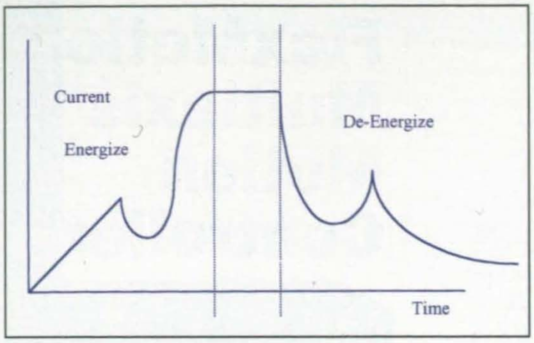


Figure 3. **Typical current signature.**

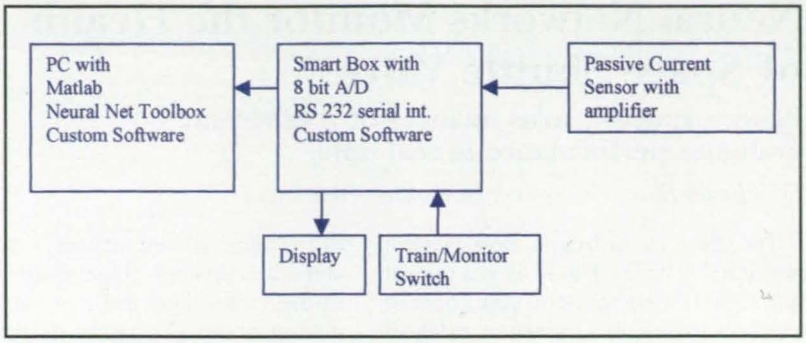


Figure 4. **System block diagram.**

(GUI) to select a suitable NN structure. The structures may have multiple inputs, outputs, and layers, and any number of neurons. The smart box is switched to "training" mode, and training is done on the valve in question. Training is achieved by activating the valve and collecting current data versus time. With each activation, the data is sent to the PC, where the user sees a plot of the current signature. The user is prompted to accept or reject this plot. If it is accepted, the user then provides the corresponding target values. All desired fault conditions must also be applied. These may be real or simulated. The raw data is processed to extract critical features. Once the desired amount of training data has been collected and processed, the results are used for defining the weights and biases of the NN. This is accomplished with Matlab from The MathWorks and the Neural Networks Toolbox (both commercially available software packages can be obtained from MathWorks).

Once an acceptable network has been defined, the structure with weights and bias information is sent to the smart box. At this point the box may be disconnected from the PC and switched to the "monitor" mode. In this mode the box automatically detects activation of the valve, collects data, preprocesses it, feeds this information to the NN, and displays the results.

The prototype system was designed for laboratory testing, but with the installation of a passive current sensor on the valve, it can adapted for flight as well. The flight data could then be used by the IVHM system for better understanding of the health history of the GH2FCV and to help predict future failures. The types of problems that the system can learn to detect include sluggish poppet, supply voltage problems, coil resistance variances, etc. Although designed specifically for the GH2FCV, the concept can be used to test similar valves that are used in the space shuttle and in other non-space critical systems. Having real-time information regarding the health of the GH2FCV reduces maintenance time and cost and extends the usable life of the valve.

This system was designed by Dr. Carl D. Latino, **Oklahoma State University,** *for NASA Kennedy Space Center's Advanced Developments and Shuttle Upgrades. The hardware was constructed and software written by students at the OSU Systems Prototyping Laboratory. The system was installed, refined, and demonstrated at NASA KSC with the help of Mario Bassignani and other KSC employees. For more information please contact Dr. Latino at (405) 744-5151; fax: (405) 744-9198; e-mail: latino@okway.okstate.edu.*

Controller for Bistable Brakes

This circuit generates pulses for switching brakes on and off.

John H. Glenn Research Center, Cleveland, Ohio

The circuit shown in the figure is a controller for bistable brakes. The use of bistable brakes reduces energy consumption and spurious heating, as explained below.

A bistable brake is one that can stay in the "on" or "off" position without consuming energy from an outside source. To switch a bistable brake from "on" to "off" or vice versa, all that is needed is a pulse of direct current with a duration of the order of 100 milliseconds. Because no power is consumed except during switching pulses, the energy consumed and the heat dissipated are much less than in the case of an ordinary electromagnetic brake.

In one application, the brakes are parts of a robot to be used in the assembly of the International Space Station. The robot contains 34 joints, each containing and actuated by a small motor/brake unit. Bistable brakes were chosen for these joints because 34 ordinary electromagnetic brakes would consume too much energy. In another application, a bistable brake is part of a droplet-deployment servo system in a droplet-combustion flight experiment; the use of the bistable brake in this system minimizes heat gain by fuel droplets.

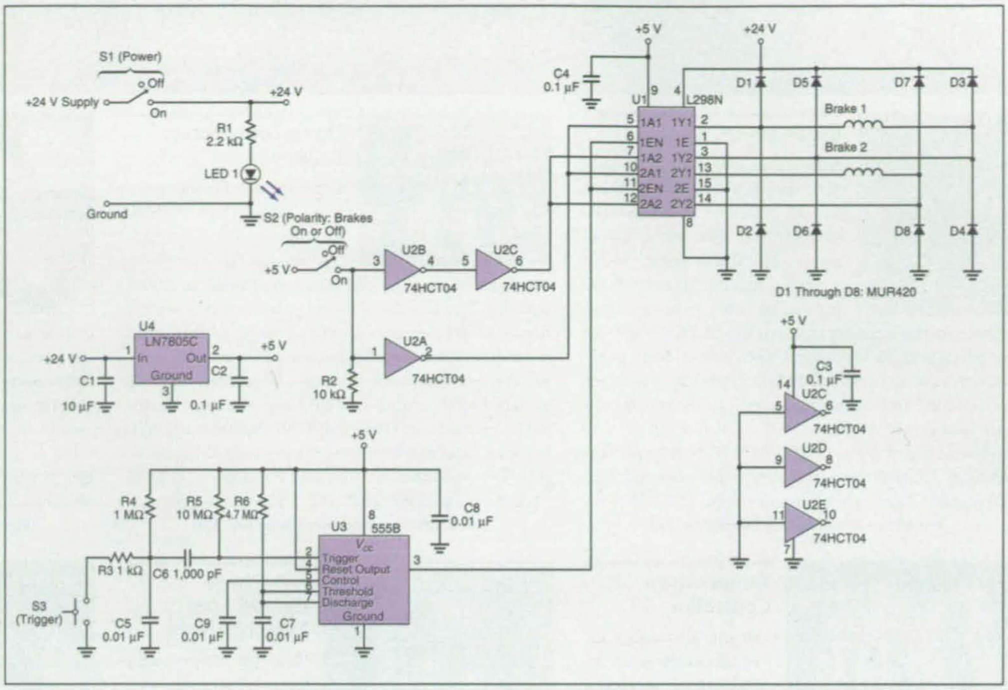
The present circuit was developed to make the best use of bistable brakes. This circuit can exert simultaneous control over two bistable brakes, each rated at a potential of 24 V and current of 2 A. The heart of the circuit is U1 — the L298N full-bridge driver. This is a high-voltage, high-current driver designed to accept standard transistor/transistor-logic (TTL) potentials and drive inductive loads. U1 is configured to provide either a positive or a negative pulse of 500-millisecond duration when activated. Switch S2 is used to

set the desired polarity through hex inverter U2, which generates the corresponding required inputs for U1. Diodes D1 through D8 serve as clamps to protect U1 against voltage spikes.

Timer U3 is configured as a monostable multivibrator to generate a clean 500-millisecond input pulse for U1 whenever switch S3 is closed. Even if switch S3 is closed for a longer time, the pulse is still no more than 500 milliseconds long; this feature helps to minimize consumption of energy.

Voltage regulator U4 generates the 5-V logic potential from the 24-V power-supply potential. The connection to the power supply is controlled by switch S1.

In operation under manual control, switch S1 is turned on first. Then switch S2 is set to obtain the polarity for turning the brakes on or off as desired. Finally, at the desired moment, switch S3 is closed to command the generation of the pulses to switch the brakes on or off. The circuit can also be adapted to operation under control by a microprocessor.



This **Bistable-Brake Controller** sends pulses of current to brakes 1 and 2 when switch S3 is closed. The polarity of the pulses is selected by closing or opening S2.

This work was done by Dennis Eichenberg and John Kolacz of **Glenn Research Center.** *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16818.

New Products

Brushless DC Motors

New from Thomson Airpax Mechatronics, Cheshire, CT, is a 98-mm series of brushless DC motors that feature a three-phase MOSFET pulse width modulation drive and surface-mounted components that eliminate the need for external controllers. Available in 26-W and 35-W outputs, the motors have peak-power capacity of up to 100 W, 50 encoder pulses per revolution, and operating speed of 100 revolutions per minute (RPM) up to 3000 RPM without dynamic balancing or up to 10,000 RPM with dynamic balancing. Thomson says the design features result in 20 percent lower overall power usage.

For More Information Circle No. 735

Open-Loop Vector Drive

Control Techniques Americas, Eden Prairie, MN, introduces the Commander SE, an AC open-loop vector drive that the company says is easy to install and use. The ten initial default parameters meet the needs of 80 percent of typical drive applications, according to Control Techniques. The Level 1 parameters can save one motor map; Level 2 and 3 parameters add flexibility and can save a second motor map, permitting the drive to sequence-switch between motors with different operating characteristics. Two models are currently available, the 230V (0.33-5 HP) and the 460V (1-5 HP).

For More Information Circle No. 736

Dedicated Field Controller

SimPro Controls, Milford, NH, makes available its SimLink™ control system that the company says dramatically simplifies and reduces the cost of single-level single-loop process control. It provides a single dedicated field controller per process that can be controlled from a PC or run autonomously. Each controller can control either an electric or a pneumatic actuator and can accept a variety of analog and digital inputs. No programming or graphical hierarchy of any kind is required. The controllers use a modular communications system that can be hardwired or wireless.

For More Information Circle No. 737

Temperature Controller

Danaher Controls, Gurnee, IL, announces the MLC9000, a bus-based temperature controller that interfaces with PLCs or Human Machine Interfaces (HMIs) to integrate temperature control and motion control. Danaher says that the unit eliminates the need for integrated PID blocks that degrade PLC performance and multiple single-loop panel-mount controllers that waste panel space and prevent centralized control. The MLC9000 communicates directly to the PLC via open buses, including DeviceNet™, PROFIBUS™, and Modbus™, or through a serial port.

For More Information Circle No. 738

Five-Phase Geared Step Motor/Driver

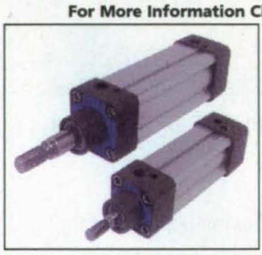
Oriental Motor USA Corp., Torrance, CA, says it has combined the UPK-W series of five-phase step motor/drivers with two new low-backlash gearheads. The company cites new technology that reduces backlash to 3 arcmin (0.05°) or less. With six gear ratios ranging from 5:1 to 50:1, the planetary gearhead is available in combination with UPK-W 2.36-in. sq. motor models, producing maximum holding torque ranging from 30.3 lb. in. with a 5:1 gear ratio to 52.0 lb.-in. with a 50:1 ratio. The UPK-W series is available with single-phase 100-115 VAC and 200-230 VAC 50/60 Hz inputs.

For More Information Circle No. 739

150-W Moving Coil Motor

Maxon Precision Motors, Burlingame, CA, says its new RE series of motors uses powerful rare-earth magnets and graphite brushes to maximize the torque that can be gotten from a 40-mm-diameter package. The patented rhombic moving-coil design provides for long life, low electrical noise, fast acceleration, and high efficiency, according to the company, and the ironless rotor enables zero cogging and simple, accurate control. The motor has three different windings available to match desired speed with available voltage. Maximum speed is 8200 RPM, and maximum efficiency is 91 percent.

For More Information Circle No. 740



Metric Air Cylinders

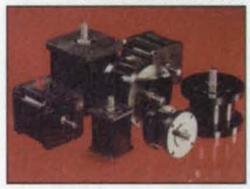
Mead Fluid Dynamics, Chicago, IL, offers its C4 series of metric air cylinders in bore sizes from 32 mm to 100 mm and with strokes to 500 mm. A dovetail slot running the full length of the barrel allows mounting of low-profile reed or Hall-effect switches. Reed switches can be used as noncontact electric switches, providing an electric signal when it senses the cylinder's magnetic position. The cylinders conform to most worldwide standards, including ISO 6431, VDMA 24562, and AFNOR NFE 49-003.

For More Information Circle No. 741

Brushless DC Motor Driver

Composite Modules Inc., Attleboro, MA, introduces the CMI-5015-48 motor control module that it says was specifically designed for operating fractional and integral horsepower motors. The plug and play module requires a single +22.0-to-+48.0-V power supply to operate a three-phase DC brushless motor. Three 15-V CMOS-compatible open-collector Hall devices are required for commutation. The internal +15.0-V reference is able to supply up to 100 mA, more than capable, the company says, for the Hall devices and additional driver circuitry.

For More Information Circle No. 742



Stepper/Servo Motor Brakes

Electroid Co., Springfield, NJ, says that its new family of front-end stepper/servo motor brakes, the Models FEB, RFEB, and SSB, was designed to offer users a choice in the sizes and features needed for specific applications. All brakes are power-off fail-safe units that mount easily to the front end of a stepper or servo motor. Electroid notes the brakes' fast response and low backlash (zero backlash on the SSB). They are available in two standard sizes to fit standard NEMA-23 and NEMA-34 motor frames. The SSB model is also available in NEMA-42. Twenty-four and 90 VDC are standard.

For More Information Circle No. 743

Low-Friction Load Cell

The new Cleveland-Kidder® Slim Cell from Cleveland Motion Controls, Cleveland, OH, measures and monitors tension on web process or wire machinery that utilizes rotating shafts or dead shaft rollers. The company says the cell is especially beneficial in load cell applications where space is tight, web tensions are typically low, and the environment is demanding. It is available in two sizes, and has force ratings from 10-2000 lb. (45-9000 N). Cleveland says the cell's low-profile design reduces the side-frame-to-side-frame width requirements of the machine.

For More Information Circle No. 744

Brushless Servo Motors

Rockwell Automation, Milwaukee, WI, is offering the Allen-Bradley MP series of brushless servo motors, which it says combine high efficiency and high torque in a compact high-density package. The series offer a variety of motor winding configurations within a given frame size to potentially reduce the output requirements of the system's servo amplifier. The MP series offers multiple feedback options, including absolute positioning and high-resolution encoders, which have the ability to position the servo system to within 1/1-millionth of a revolution.

For More Information Circle No. 745

Locking-Style Safety Switches

Banner Engineering Corp., Minneapolis, MN, announces its SI-LS42 series of locking-style safety switches that can be wired to machine safety control circuitry to keep a mechanical guard locked at up to 1000 N of force until hazardous motion has come to a stop. Banner says they are suitable for use with two-channel emergency stop and gate monitor safety modules. Features include a choice of two locking mechanisms (spring lock with energized solenoid release or energized solenoid lock with spring unlock); two stainless steel actuator types (rigid in-line or flexible in-line); and a choice of solenoid voltages (24 V AC/DC or universal voltage 24-48 V AC/DC or 24-230 V AC).

For More Information Circle No. 746

Vol. 24, No. 4 April 2000 This form expires: September 30, 2000

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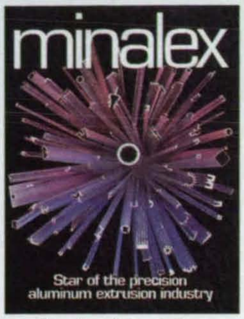

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National Instruments

For More Information Circle No. 611

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National Instruments

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For More Information Circle No. 614

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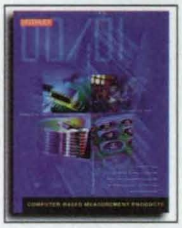
This catalog is packed with products for engineering design, research and development, prototypes and modeling, and industrial assembly. Thousands of items are in stock, including miniature fasteners, specialty components, fluid and motion control devices, select materials, and precision tools. SMALL PARTS, INC., 13980 NW 58th Court, Miami Lakes, FL, 33014, Attn: Free Catalog - Dept. 200F; Tel: 800-220-4242; Fax: 800-423-9009; www.smallparts.com

SMALL PARTS, INC.

For More Information Circle No. 616



KEITHLEY'S 2000/2001 CATALOG

Keithley's 2000/2001 catalog of computer-based measurement products provides specifications, selection guides, and background on measurement techniques. Products include voltage, current, and resistance meters; sources, switches, software, real-time control hardware, signal conditioning hardware; acquisition, digital I/O, and motion control boards; and semiconductor products. Keithley Instruments, Inc., 28775 Aurora Rd., Cleveland, OH 44139; Tel: 1-888-KEITHLEY; www.keithley.com

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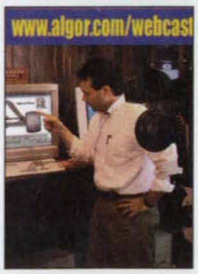
Algor, Inc.

For More Information Circle No. 619



TUESDAYS AT TEN: ALGOR LIVE WEBCASTS

Join Algor every Tuesday at 10:00 a.m. Eastern Time for a live Webcast to learn more about Algor's software from the most basic to full Mechanical Event Simulation. Engineers can phone or email questions to be answered by Algor engineers during the Webcast. Address: 150 Beta Dr., Pittsburgh, PA 15238; Phone: +1 (412) 967-2700; Email: webcast@algor.com; or Fax: +1 (412) 967-2781; www.algor.com/webcast

Algor, Inc.

For More Information Circle No. 620

ALGOR SOFTWARE ELIMINATES TIME & COST OF PERFORMING PHYSICAL TESTS

Use Algor's Mechanical Event Simulation (MES) and kinematic element technology to simultaneously replicate motion and flexing for linear and nonlinear events on CAD solid models. MES eliminates the need to determine forces by external calculation because it does not require internal dynamic loading input. Use InCAD*Plus* to import designs from popular CAD solid modelers into Algor's MES. 150 Beta Drive, Pittsburgh, PA 15238-2932; Phone: +1 (412) 967-2700; Fax: +1 (412) 967-2781; E-mail: info@algor.com; website: www.algor.com

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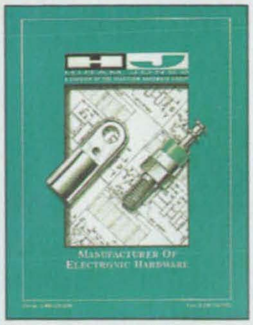

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National Electrostatics Corp.

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OMEGA Engineering

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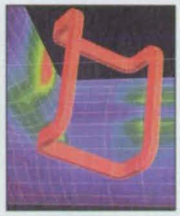

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WinWedge instantly inputs serial (RS232-RS485) or TCP/IP data into any Windows application: Excel, Access, MMIs, etc. Collect data from and control gauges, micrometers, balances, meters, bar-code scanners, measuring instruments ... any device. Easily perform graphing and analysis of your instrument data in any program. TalTech, 2027 Wallace St., Philadelphia, PA 19130; Tel: 800-722-6004, 215-763-7900; Fax: 215-763-9711; www.taltech.com

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DC/DC CONVERTERS

The new Model FE-280A Series of DC/DC Converters offers up to 20 watts of power in a small aluminum case. Units are available in single, dual, or triple outputs. All units include input and output filtering to meet stringent EMI requirements. The converter can offer regulation of better than 1% at end of life, typical 12-year mission. Frequency Electronics, Inc., 55 Charles Lindbergh Blvd., Mitchel Field, NY 11553; Tel: 516-794-4500; Fax: 516-794-4340

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COATING PROTECTS MAGNESIUM PARTS

MAGNADIZE® surface-enhancement coatings increase surface hardness and provide permanent dry lubricity to protect magnesium parts against abrasion, wear, and corrosion from chemicals and/or moisture. Magnaplate-applied MAGNADIZE eliminates oxidizing and galling, two critical problems for magnesium. Available in four thicknesses, the coating also exhibits high dielectric strength and excellent release properties. General Magnaplate, Linden, NJ 07036; Tel: 800-852-3301; Fax: 908-862-6110; e-mail: info@magnaplate.com; www.magnaplate.com

General Magnaplate

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30 MHZ FUNCTION AND ARBITRARY WAVEFORM GENERATOR

The DS345 creates synthesized (DDS) sine, square, triangle, and ramp waveforms with 1μHz frequency resolution. Arbitrary waveforms of up to 16k points with 12-bit resolution can also be generated. Capabilities include AM, FM, PM, and burst mode as well as linear and logarithmic frequency sweeps. The GPIB and RS-232 interface option provides easy communication with computers and includes software for creating arbitrary waveforms. U.S. list price: $1,595. Stanford Research Systems; Tel: 408-744-9040; Fax: 408-744-9049; e-mail: info@thinkSRS.com; www.thinkSRS.com

Stanford Research Systems

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These new Type PFT™ metal/plastic thumbscrews feature stainless-steel threads with a 6-lobe recess, overmolded with a black ABS cap. The cap has external lobes that can be grasped easily for finger operation and features a generous slot for use with a tool. Optional colors are available. Penn Engineering and Mfg. Corp.; Tel: 800-237-4736; Fax: 215-766-0143; www.pemnet.com

Penn Engineering and Mfg. Corp.

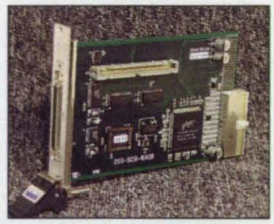
For More Information Circle No. 633

New on the MARKET

Data Acquisition and Control

National Instruments, Austin, TX, has introduced a data acquisition and control system based on PXI/ Compact PCI and the LabVIEW RT graphical programming environment for development and deployment of embedded, real-time applications. LabVIEW RT enables users to develop high-speed data acquisition, control, test, and discrete and process control applications on a standard Windows PC. A pull-down menu command will download the applications across an Ethernet network to run deterministically on a PXI/Compact PCI embedded controller. Once embedded, LabVIEW RT applications acquire analog and digital I/O via National Instruments data acquisition and signal conditioning modules plugged into the PXI system chassis. **Circle No. 727**

CompactPCI Controller



The 3U CompactPCI SCSI-3 controller with rear I/O from One Stop Systems, Escondido, CA, provides transfer rates up to 133 MB/second with synchronous transfer rates to SCSI peripherals up to 40 MB/second. The controller includes two 16-bit Ultra SCSI-3 connectors, one channel (Channel A) routed through the front panel, and the second channel (Channel B) routed through the rear J2 connector. The controller utilizes a PCI-to-SCSI bridge equipped with an embedded RISC engine, which reduces CPU overhead associated with CPU-to-SCSI transfers. **Circle No. 729**

Pressure-Sensitive Tapes

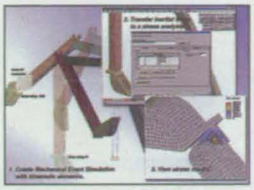
CS Hyde, Lake Villa, IL, offers Teflon® and Kapton® tapes designed specifically for longer life and higher output. The tapes are used wherever a non-stick, heat- and chemical-resistant surface is required. Their release qualities and surface consistency withstand extremely high temperatures and operating speeds. Kapton® is used in electrical applications for insulation, conformability, and high dielectric strength. UHMW pressure-sensitive tape has a high slip surface with a low friction coefficient. It can be used to reduce abrasion, noise, and friction. **Circle No. 732**

Recorder-Workstation

The Everest telemetry recorder-workstation from Test and Measurement Systems, Astro-Med, West Warwick, RI, is designed for aerospace applications such as flight testing and satellite telemetry. Features include an 18" color display for real-time data viewing; intuitive touch-screen interface; 32 analog or digital input channels; high-resolution chart; and Virtual Chart™ for saving large amounts of data to an on-board hard drive. Waveforms can be viewed from any angle on the customizable display; different colors can be used for waveforms, grids, timing marks, and text. An alarm feature can change the waveform color or sound a tone when signals exceed specified limits. **Circle No. 733**

New on DISK

Inertial Load Transfer



The Inertial Load Transfer Extender from ALGOR, Inc., Pittsburgh, PA, is part of the Mechanical Event Simulation (MES) line of products that provide faster, more accurate stress results from the inertial loading created during a dynamic event. It allows users to simulate dynamic behavior, calculate inertial loads at each node, and perform a linear or nonlinear static stress analysis using one finite element model to determine stresses. The software automatically creates a static stress analysis model, maintaining the orientation of the geometry for the selected time-step, and then transfers the inertial loads at each node. Engineers can filter the forces and moments to be transferred by magnitude to eliminate inconsequential loads from the new analysis. **Circle No. 704**

Data Analysis and Visualization

Research Systems, Boulder, CO, has released IDL (Interactive Data Language) Version 5.3 data analysis, visualization, and cross-platform application development software. The upgrade expands features in the language, including visualization and analysis, file I/O, the IDL GUIBuilder, and IDL ActiveX Control. Image-processing improvements are designed to increase capabilities in quantitative image analyses. The more than 30 new analysis routines include a set of polygon mesh routines and mesh utilities for use with large 3D data sets. IDL 5.3 also supports GZIP file compression/decompression. **Circle No. 700**

Motion Control Programming

MotionPro™ software from Industrial Indexing Systems, Victor, NY, is designed to program DeltaPro™ single-axis positioning systems. Programs are built in a block step format; there are 127 blocks plus an additional five special blocks to permit automatic execution of code during transitions between modes. Thirty-two different commands are represented by icons in a toolbox. When a command is selected, a default screen prompts the programmer to enter parameters for that command. Files can be created to save/store programs, which can then be downloaded to and uploaded from the positioning system. **Circle No. 701**

Project Communication

Framework Technologies, Burlington, MA, has introduced ActiveProject™ v2000/E project communication software that enables organizations to set up project extranets for streamlining communication and project delivery with an extended team of internal constituents and external partners. It combines secure, centralized access to project data with an integrated set of collaborative applications. Features include optional back-end support for Oracle and SQL Server Databases; publishing of SolidWorks® CAD assemblies as smart, navigable Web pages; and the ability to access multiple projects from a single Web page. **Circle No. 702**

Data Acquisition

Agilent Technologies, Palo Alto, CA, offers version 2.0 of DAC Express data acquisition/recorder software that provides simultaneous digital and counter totalize measurements for testing of devices such as pumps and motors. DAC Express setup/data viewer software allows users to review recorded data files and create new test setups at a remote PC. Because no programming is necessary, the software streamlines the process of system development, data collection/validation, archiving, analysis, and report generation. The programs can export data files in MATLAB and Microsoft Excel formats. **Circle No. 705**

New LITERATURE

Microelectronics Guide

Master Bond, Hackensack, NJ, offers a four-page application selector guide on adhesives, sealants, coatings, and encapsulants specially formulated for microelectronics. The guide covers both one- and two-component systems, including epoxies, silicones, acrylics, and latex. Viscosity, set-up times, cure schedules, service operating temperature ranges, and application recommendations are listed for 70 different grades. **Circle No. 707**

Industrial PC Systems

A 43-page catalog from I-Bus, San Diego, CA, describes industrial computer solutions, including CPU boards, systems enclosures, passive backplanes, CompactPCI™ boards and enclosures, rack-mount products, peripheral options, and rack-mount power conditioners. Specialty products include CD-ROM shares, floppy shares, and embedded enclosures. **Circle No. 708**

Metal Powders

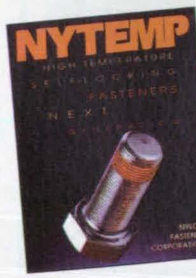
Hoeganaes Corp., Cinnaminson, NJ, offers a brochure that illustrates production of sponge and atomized ferrous-metal powders and outlines their properties and typical uses. Applications include pharmaceuticals, food, welding, plastics, chemicals, metallurgy, friction, reprographics, and printing. **Circle No. 709**

DC Power Supplies

Xantrex Technology, Burnaby, BC, Canada, has released a catalog of programmable DC power supplies. A white-paper technical report on soft switching is included, along with application notes, technical ordering information on customization, testing, and standard and optional control interfaces. Applications include automotive, aerospace, semiconductor, medical electronics, semiconductor, military electronics, and telecommunications. **Circle No. 710**

True Position Locators

A selection guide from LaVezzi Precision, Glendale Heights, IL, describes Tru-Pos™ True Position Locators, designed for determining the true position of tapped holes for CMM inspection applications. The locators reference the pitch diameter, thereby offering an accurate reading. They are available in straight-thread design for seating on a flat surface and a tapered style for irregular or cast surfaces. **Circle No. 711**



Self-Locking Patch

Nylok Fastener Corp., Macomb, MI, has published a brochure on NYTEMP® patented orange polymer self-locking patches. They are designed to maintain torque and clamp load at temperatures up to 450 °F, and meet or exceed most government, military, and industry specifications. They can be used in small engines, appliances, and automated assembly operations. **Circle No. 712**

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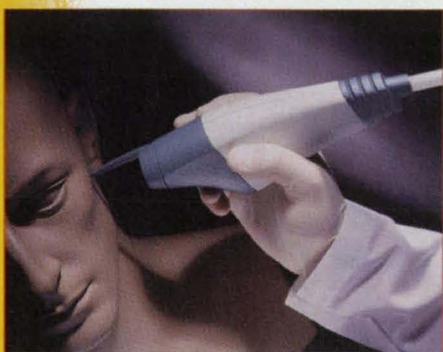
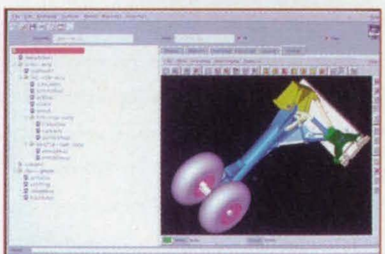
This Month in

Rapid Product Development online

Tools & Techniques To Create Better Products Faster

The web publication for *NASA Tech Briefs* readers





NASA Tech Briefs' totally digital publication, Rapid Product Development Online (**www.rapidproducts.net**), helps engineers develop better products faster by giving them immediate, 24-hour access to the latest information on CAD, FEA, modeling, reverse engineering, and rapid prototyping tools and techniques.

RPD Online includes feature stories, industry and product news, product reviews, show coverage, demos, links, and a keyword-searchable supplier guide.

This month's RPD Online includes:

- **Cross-Platform CAD Program Helps Air Force Engineers Cut Detailing Time** — Engineers at the Air Force Research Lab are able to produce more accurate, detailed manufacturing drawings using CAD software.
- **Desktop Parts "Printer" a Major Component in Design of Surgical Laser** — Severe cost and time requirements were met in the design of a surgical laser tool using a compact system that creates 3D models.
- **Show Update** — A profile of the latest RPD innovations displayed at National Manufacturing Week's Rapid Prototyping Pavilion.
- **New Products** — CAM and data conversion software, a coordinate measuring machine, rubber mold materials, and product development services are among the new products featured this month.

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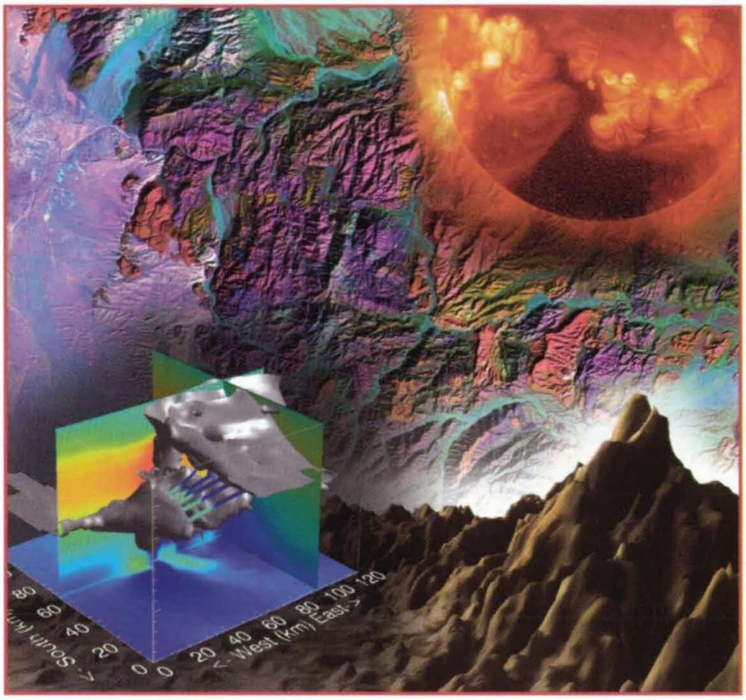
The Power of IDL



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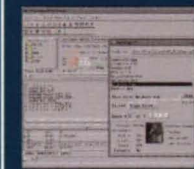
For More Information Circle No. 508

Research Systems offers off-the-shelf software packages built with IDL that deliver analysis and results with point-and-click ease.



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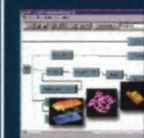

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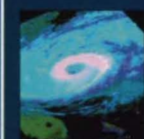

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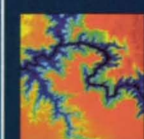

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